STATE OF TENNESSEE

DEPARTMENT OF ENVIRONMENT AND CONSERVATION

Division of Water Pollution Control

Quality System Standard Operating Procedure

for

CHEMICAL AND BACTERIOLOGICAL SAMPLING OF SURFACE WATER

August 2011

This SOP is an intra-departmental document intended to govern the internal management of the Tennessee Department of Environment and Conservation and to meet requirements of the U.S. Environmental Protection Agency for a quality system. It is not intended to affect rights, privileges, or procedures available to the public.

DIVISION OF WATER POLLUTION CONTROL
QUALITY SYSTEMS STANDARD OPERATING PROCEDURES
FOR CHEMICAL AND BACTERIOLOGICAL SAMPLING
OF SURFACE WATER

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DIVISION OF WATER POLLUTION CONTROL

QUALITY SYSTEM STANDARD OPERATING PROCEDURE FOR CHEMICAL AND BACTERIOLOGICAL SAMPLING OF SURFACE WATER

TITLE AND APPROVAL PAGE

DOCUMENT TITLE	Quality System Standard Operating Procedure for Chemical & Bacteriological Sampling of Surface Water
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PLAN COVERAGE	General instructions for chemical and bacteriological sampling of surface waters and measurement of water parameters, flow and quality control in Tennessee.

APPROVALS AND CONCURRENCES

Approvals. This is to certify that we have reviewed this document and approve its contents.

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REVISIONS AND ANNUAL REVIEW PROCEDURE: QS-SOP FOR CHEMICAL AND BACTERIOLOGICAL SAMPLING OF SURFACE WATER

1. This document shall be reviewed annually to reconfirm the suitability and effectiveness of the program components described in this document.

2. A report of the evaluation of effectiveness of this document shall be developed at the time of review and submitted to appropriate stakeholders. Peer reviews shall be conducted, if necessary and appropriate. It shall be reconfirmed that the document is suitable and effective. It shall include, if necessary, clarification of roles and responsibilities, response to problem areas and acknowledgement of successes. Progress toward meeting TDEC–BOE mission, program goals and objectives shall be documented. Plans shall be made for the upcoming cycle and communicated to appropriate stakeholders.

3. The record identified as "Revisions" shall be used to document all changes.

4. A copy of any document revisions made during the year shall be sent to all appropriate stakeholders. A report shall be made to the Deputy Commissioner and Quality Assurance Manager of any changes that occur. Other stakeholders shall be notified, as appropriate and documented on the "Document Distribution" list.

NOTICE OF REVISIONS RECORD

Date	Specific Section or Page	Revision Type	Revision Description
06/05/08	Throughout Document	Minor	Numerous employee, positions and titles were updated.
06/05/08	Throughout Document	Minor	Change Environmental Assistance Center (EAC) to Environmental Field Office (EFO).
06/05/08	I.A.	Minor	Clarified Tennessee Statutory Authority.
06/05/08	I.C.	Minor	Added and revised definitions.
06/05/08	I.D.	Minor	Clarified health and safety warnings.
06/05/08	I.E.	Minor	Clarified Cautions.
06/05/08	I.F.	Minor	Clarified Interferences, added atmospheric metals.
06/05/08	I.H.	Minor	Added field barometer, boat safety equipment and automatic sampling equipment to equipment lists.
06/05/08	I.H	Major	Revised sample container acquisition procedure.
06/05/08	I.H.	Minor	Clarified sample container descriptions.
06/05/08	I.H. Table 2	Major	Revised TOC bottle requirements.
06/05/08	I.H. Table 3	Major	Increased number of required volatile vials from four to five.
06/05/08	1.H.	Major	Removed bottle preparation procedure.
06/05/08	1.H.	Minor	Clarified cooler and bucket cleaning procedures.
06/05/08	I.I. Table 4	Major	Updated recommended parameter list for Surface Water Samples.
06/05/08	I.I. Table 5	Minor	Specified Certified Clean single-use sample containers.
06/05/08	I.I Protocol A	Minor	Clarified decision making process for requesting *E. coli* dilutions.
06/05/08	I.I Protocol A	Minor	Provided more detail for site selection process.
06/05/08	I.I Protocol B	Minor	Added clarification for determining river mile.
06/05/08	I.I Protocol B	Major	Added protocol for assigning station Ids to unnamed tributaries of unnamed tributaries, wetlands, sinking streams, reservoirs, lakes and QC samples.
06/05/08	I.I Protocol C	Minor	Clarified sample procedures for isolated pools, drought and large rivers/streams.

NOTICE OF REVISIONS RECORD

06/05/08	I.I. Protocol C	Major	Changed sample temperature requirements.
06/05/08	I.I. Protocol C Table 7	Major	Revised holding time for routine and TCLP samples. Revised TOC sample container requirements. Increased number of volatile vials required.
06/05/08	I.I. Protocol C	Minor	Added custody seal information.
06/05/08	I.I. Protocol C	Major	Added state laboratory requirements for sample delivery.
06/05/08	I.I. Protocol C	Minor	Added primary sampler requirement to sample tag.
06/05/08	I.I. Protocol C	Major	Clarified bacteriological sample collection procedure including dilution requests and air space requirements.
06/05/08	I.I. Protocol C	Major	Added TOC sampling protocol.
06/05/08	I.I. Protocol C	Major	Revised Volatile sample collection procedure.
06/05/08	I.I. Protocol D	Minor	Refined field cleaning procedures for sampling equipment.
06/05/08	I.I. Protocol H	Minor	Added more details to sample identification tag procedure.
06/05/08	I.I. Protocol I	Minor	Added more details to sample request form procedure.
06/05/08	I.I. Protocol J	Major	Revised protocol for Instantaneous Field Parameters including minimum probe specifications, meter calibration and drift checks.
06/05/08	I.I. Protocol K	Major	Revised protocol for Continuous Monitoring Field parameters including minimum probe specifications and drift checks.
06/05/08	I.I. Protocol L	Minor	Added detail to flow measurement procedure and added dye tracer flow measurement method for use in some TMDLs.
06/05/08	I.I. Protocol M	Minor	Added clarification to bacteriological analyses conducted by EFO.
06/05/08	II.A.	Major	Added responsibilities for In-house QC officer including problem resolution.
06/05/08	II.B.	Minor	Added detail on collection of trip blank and field blanks.
06/05/08	II B.	Minor	Added more detail on how to complete the sample request form for QC samples.
06/05/08	II B.	Minor	Added sterilization of water for field and trip blanks as a step in resolving sample contamination.

NOTICE OF REVISIONS RECORD

06/05/08	II.C.	Minor	Specified the primary sampler must sign chain of custody.
06/05/08	III.	Minor	Updated references.
06/05/08	Appendix A	Major	Replaced TDH Environmental Laboratories Sample Container Request Form.
06/05/08	Appendix A	Minor	Added an example of completed sample request form.
06/05/08	Appendix B	Major	Revised sample temperature requirements for TDH bacteriological Analyses.
06/05/08	Appendix B	Major	Revised TDH Available Routine Analyses.
06/05/08	Appendix B	Major	Revised TDH Available Nutrient Analyses.
06/05/08	Appendix B	Major	Revised TDH Available Metals Analyses.
06/05/08	Appendix B	Major	Revised TDH Available Miscellaneous Inorganic Analyses.
06/05/08	Appendix B	Major	Revised TDH Available Organic Analyses.
06/05/08	Appendix C	Major	Revised TMDL monitoring sample list.
06/05/08	Appendix C	Major	Added protocol for storm event characterization.
11/17/09	Throughout Document	Minor	Numerous employees, positions and titles were updated.
11/17/09	I. C.	Major	Revised storage time for organic-free reagent water (blank water).
11/17/09	I. D.	Minor	Replaced the words “Life Jacket” with the acronym “PDF”.
11/17/09	I. D.	Minor	Added info pertaining to law enforcement and listed THP phone numbers
11/17/09	I. E.	Major	Added that meters should minimally be calibrated once a week.
11/17/09	I. E.	Major	Added caution to collect chemical and biological samples on same day if possible.
11/17/09	I.F.	Major	Changed post-trip drift check for D.O. from 5% to 10%.
11/17/09	I.F.	Minor	Reworded Interferences # 9 and 10.
11/17/09	I.H.	Minor	Changed to recommend ordering bottles two weeks prior to sampling, not one week.

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11/17/09	I.H.	Major	Changed calibration of meters from “morning of sampling” to “prior to sampling (minimally once a week."
11/17/09	I.H.	Minor	Added Extra bottles and State I.D. to general field equipment list.
11/17/09	I.H.	Minor	Changed custody seal from “necessary” to “if required”
11/17/09	I.H.	Minor	Changed to recommend ordering bottles two weeks prior to sampling, not one week.
11/17/09	I.H.	Major	Reverted sample container acquisition procedure back to the 2007 version.
11/17/09	I.H.	Minor	Added that multiple buckets may be taken in the field to avoid cleaning between sites.
11/17/09	I.H.	Minor	Corrected reference to a procedure in another section.
11/17/09	I.H. Table 3	Major	Revised TOC bottle requirements.
11/17/09	I.I. Protocol A, Table 5	Major	Revised flow requirements for TMDL monitoring of pathogens.
11/17/09	I.I. Protocol A, Table 5	Major	Added Selenium as a requirement for TMDLs and reference (Eco & Feco) sites.
11/17/09	I.I. Protocol A, Table 5	Major	Added multiple parameters as optional for 303(d) monitoring.
11/17/09	I.I. Protocol A,	Major	Changed the *E. coli* dilution requirement based on historical data to match the count ranges for the Colilert test method.
11/17/09	I.I. Protocol A	Major	Revised protocol for assigning station IDs when sampling for chemicals and biology the same location.
11/17/09	I.I. Protocol B	Major	Revised protocol for assigning station IDs when sampling chemicals and biology the same location.
11/17/09	I.I. Protocol B	Major	Added protocol to use the stream name from a USGS topo map when assigning station IDs.
11/17/09	I.I. Protocol B	Minor	Added comment about measuring river miles.
11/17/09	I.I. Protocol B	Minor	Added abbreviations and underscore _ to Station IDs that are out-of-state
11/17/09	I.I. Protocol B	Major	Added protocol for naming unnamed streams within a geographical feature.
11/17/09	I.I. Protocol B	Minor	Corrected example on naming unnamed sinking streams.
11/17/09	I.I. Protocol B	Minor	Changed wording of Number 8, Example 2

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11/17/09	I.I. Protocol C	Minor	Changed wording of sentence regarding drought conditions.
11/17/09	I.I. Protocol C	Major	Revised sampling protocol regarding the thalweg and collecting samples from banks or docks.
11/17/09	I.I. Protocol C	Major	Added sampling protocol for the collection of dissolved metals.
11/17/09	I.I. Protocol C Table 8	Major	Revised TOC bottle requirements.
11/17/09	I.I. Protocol C	Minor	Removed rubber band requirement for TOC vials.
11/17/09	I.I. Protocol D	Major	Added information about sampling outside of the thalweg.
11/17/09	I.I. Protocol D	Major	Added protocol for sampling order.
11/17/09	I.I. Protocol E	Major	Added protocol for sampling order.
11/17/09	I.I. Protocol E	Major	Removed sentence: "Rinse the probes with water (tap water) after use at each site to decrease the chance of contamination."
11/17/09	I.I. Protocol F	Minor	Removed repeated information.
11/17/09	I.I. Protocol F	Major	Added a rope and bottle holder as a sampling device from a bridge.
11/17/09	I.I. Protocol F	Major	Added protocol for sampling order.
11/17/09	I.I. Protocol G	Minor	Added safety precaution relating to latex gloves.
11/17/09	I.I. Protocol H	Major	Added to write the name of the waterbody in the "Station Location" field on the sample I.D. tag
11/17/09	I.I. Protocol H	Minor	Changed that samplers must write (not sign) their full name in the "Samplers" field on the sample I.D. tag.
11/17/09	I.I. Protocol I	Minor	Added that pre-printed and copied forms can be used as a sample request form.
11/17/09	I.I. Protocol I	Major	Added to write the name of the waterbody in the "Description" field on the sample request form.
11/17/09	I.I. Protocol I	Major	Added protocol to record temperature reading if a temperature correction factor was applied.
11/17/09	I.I. Protocol I	Minor	Added to #4. b. (7) "If a custody seal is required"
11/17/09	I.I. Protocol I	Major	Removed sentence: "Rinse the probes with water (tap water) after use at each site to decrease the chance of contamination."

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11/17/09	I.I. Protocol J	Major	Added that drift checks can be done in the field.
11/17/09	I.I. Protocol K	Minor	Reworded #10. Data Interpretation.
11/17/09	I.I. Protocol L	Major	Revised flow requirements for TMDL monitoring of pathogens.
11/17/09	I.I. Protocol L	Major	Added that calibrated gauging stations may be used to measure flow.
11/17/09	I.I. Protocol M	Major	Revised pathogen log number assignments.
11/17/09	I.I. Protocol M	Minor	Added formatting for dates when logging pathogen samples.
11/17/09	I.J.	Minor	Revised storage times for sampling data.
11/17/09	II. B	Major	Added protocol for blank water containers for organic analysis.
11/17/09	II. B	Major	Added storage information for blank water.
11/17/09	II. B	Major	Added information on recording time for duplicates.
11/17/09	References	Minor	Added reference for IDEXX Laboratories procedure.
11/17/09	Appendix A	Major	Added abbreviations for samples collected out-of-state
11/17/09	Appendix B	Major	Changed bottle requirements for hardness from 1-L routine to 500 mL nutrient.
11/17/09	Appendix B	Major	Revised holding time for total coliform.
11/17/09	Appendix B	Major	Revised holding time for conductivity.
11/17/09	Appendix B	Major	Revised holding time and MDL for nitrate.
11/17/09	Appendix B	Major	Revised holding time and MDL for nitrite.
11/17/09	Appendix B	Major	Revised holding time for silica.
11/17/09	Appendix B	Major	Revised MDL for sulfate.
11/17/09	Appendix B	Major	Revised MDL for apparent color.
11/17/09	Appendix B	Major	Revised MDL for true color.
11/17/09	Appendix B	Major	Revised MDL for COD.
11/17/09	Appendix B	Major	Revised MDL for nitrogen, ammonia.
11/17/09	Appendix B	Major	Revised MDL for nitrogen, NO_3 & NO_2.

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11/17/09	Appendix B	Major	Revised MDL for total Kjeldahl nitrogen.
11/17/09	Appendix B	Major	Revised MDL for total organic nitrogen.
11/17/09	Appendix B	Major	Revised MDL for total phosphorus.
11/17/09	Appendix B	Major	Revised MDL for antimony, Sb.
11/17/09	Appendix B	Major	Revised MDL for Cadmium, Cd.
11/17/09	Appendix B	Major	Revised MDL for Magnesium, Mg.
11/17/09	Appendix B	Major	Revised MDL for Selenium, Se.
11/17/09	Appendix B	Major	Revised MDL for Mercury, Hg. Also added MDL for the Jackson Regional Lab.
11/17/09	Appendix B	Major	Revised holding time and MDL for TOC.
11/17/09	Appendix C	Major	Revised flow requirement for TMDL monitoring of pathogens.
6/2/11	I.F. and I.H.	Minor	Added that gloves are required for routine metals and mercury sampling.
6/2/11	I.I. Protocol A (Table 5)	Minor	Clarified that the parameters marked with an asterisk are for established FECO sites.
6/2/11	I.I. Protocol B	Major	Revised protocol for assigning station ID numbers and added two figures.
6/2/11	I.I. Protocol B	Major	Clarifications on how to measure river miles, specifically ones that flow through an embayment.
6/2/11	I.I. Protocol C	Minor	Added that gloves are required for routine metals and mercury sampling.
6/2/11	I.I. Protocol J	Major	Added procedure on what to do if field parameter equipment fails in the field.
6/2/11	I.I. Protocol J	Minor	Changed how often the WQ database is sent from PAS to EFOs and Lab. Monthly instead of quarterly.
6/2/11	I.I. Protocol L	Major	Added that flow need to be measured at Ecoregion and FECO reference sites.
6/2/11	II.C.	Major	Added procedure to determine potential contamination of blank results.
6/2/11	Appendix A (Flow Sheet)	Minor	Added that the final flow measurement needs to be rounded to two decimal places.
6/2/11	Appendix B	Minor	Revised MDLs for Sodium, Vanadium, and Zinc.
6/8/11	I.H. I.I., Protocol C Appendix B	Major	Corrected cyanide preservative technique.

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7/19/11	Throughout	Major	Required the use of nitrile gloves for metals sampling.
7/19/11	Throughout	Major	Revised Cyanide preservation procedure.
7/19/11	I.I. Protocol A	Major	Added QC blank parameter list to Table 5.
7/19/11	I.I. Protocol C	Minor	Added that if Mercury samples are sent to the Jackson Lab, collect in a 500mL plastic bottle.
7/19/11	I.I. Protocol I	Minor	Added to include Central Office QC Coordinator on Sample Request Form under "Send Report To".
7/19/11	II. B	Major	Added clarification on QC Samples.
7/19/11	Appendix C	Minor	Broke out the current Laboratory MDLs into separate tables from the "Analyses Available" tables.

This revision(s) has been reviewed and approved. It becomes effective August 2011.

7-21-11

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Project Manager
WPC QSSOP for Chemical and Bacteriological Sampling of Surface Water

Date

7/21/11

Paul E. Davis
Director
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7/22/11

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EVALUATION PROCEDURE: QS-SOP FOR CHEMICAL AND BACTERIOLOGICAL SAMPLING OF SURFACE WATER

As this document is used, needed changes or improvements will be apparent. Specific recommendations for improvements or changes are solicited as well as information concerning typographical or formatting errors.

1. Copy this page and complete all questions. Electronic versions are encouraged especially if comments are significant.

2. Send specific recommendations for improvements or changes, along with the following information, to:

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QS-SOP DOCUMENT DISTRIBUTION LIST

Copies of this document were distributed to the following individuals in TDEC and TDH. Additional copies were distributed to non-TDEC agencies and individuals upon request (including other state and federal agencies, consultants, universities etc.). An updated distribution list is maintained in the Planning and Standards Section.

The system for document distribution is described in TDEC-BOE Quality Manual, Chapters 5 and 10.

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PREFACE

The U.S. EPA requires that a centrally planned, directed and coordinated quality assurance and quality control program be applied to efforts supported by them through grants, contracts or other formalized agreements. This includes the implementation of a Quality Management Plan as written by the contract holder with Data Quality Objectives (DQOs) set in Quality Assurance Project Plans (QAPPs) for specific projects. The organization may elect to support portions of the QAPP through technical or administrative standard operating procedures (SOPs), as specified by the quality system. As a contract holder and through memoranda of agreement, the Tennessee Department of Environment and Conservation is required to maintain such a system.

This Quality System technical Standard Operating Procedure (QS-SOP) was prepared, reviewed, and distributed in accordance with TDEC's Quality Management Plan and other quality system documents in response to U.S. EPA's requirements for a Quality Management Program. QS-SOPs are integral parts of successful quality systems as they provide staff with the information to perform a job properly and facilitate consistency in the quality and integrity of the process.

This QS-SOP is specific to the Division of Water Pollution Control, is intended to assist the division in maintaining their quality control and quality assurance processes, and ensures compliance with government regulations. It provides specific operational direction for the division's Quality Assurance Project Plan for Chemical and Bacteriological Sampling of Surface Water.

This document will be reviewed annually and revised as needed. Always use the most recent version.

I. PROCEDURES

I.A. Scope, Applicability and Regulatory Requirements

The purpose of this Quality Systems Standard Operating Procedure (QS-SOP) is to support the Quality Assurance Program. The document provides a consolidated reference document for use in training and orientation of employees. This guide will also be a reference tool for more experienced employees. It establishes an approach that can be recommended to sister agencies that monitor Tennessee water or stipulated to members of the regulated community given monitoring requirements in receiving waters. This SOP describes the chemical and bacteriological surface water collection process and delineates all steps in the process including water sample collection, quality control sample collection, documentation, water parameters and flow measurement. This SOP is only intended to describe routine conditions encountered during a surface water-sampling event.

The purpose of this SOP is not to supersede professional judgment, but rather is intended to ensure that appropriate sampling methods and quality assurance procedures are employed. Discuss any deviations from the protocols outlines in this SOP with the in-house EFO QC officer for chemical and bacteriological sampling or the central office QC coordinator. Document any departure from this protocol.

Federal Statutory Authority

Federal Water Pollution Control Act (amended through P.L. 106-308, October 13,2000) as Amended by the Clean Water Act of 1977 enacted by Public Law 92-500, October 18, 1972, 86 Stat. 816; 33 U.S.C. 1251 et. seq.
Title III, Sec. 302: Water Quality Related Effluent Limitations
Title III, Sec. 303: Water Quality Standards and Implementation Plans
Title III, Sec. 304: Information and Guidelines
Title III, Sec. 305: Water Quality Inventory

Tennessee Statutory Authority

Tennessee Water Quality Control Act of 1977 (Acts 1971, ch. 164, § 1; 1977 ch. 366, § 1; T.C.A., § 69-3-101, et seq.).

Tennessee Regulatory Authority

General Water Quality Criteria and the Antidegradation Statement: Rule 1200-4-3 (specifically 1200-4-3-.03, Criteria for Water Use and 1200-4-3-.06, Tennessee Antidegradation Statement)
Use Classifications for Surface Waters: Rule 1200-4-4.

I.B. Summary of Method

This document describes procedures approved by the Division of Water Pollution Control for collecting chemical and bacteriological samples of surface water. The objective of surface water sampling is to obtain a representative sample that does not deteriorate or become contaminated before it is analyzed. To verify the accuracy and representativeness of sample analyses, proper sample collection and preservation techniques, and appropriate quality control measures must be followed.

Protocols are explained for collecting a representative sample using the appropriate sample container, preservative, and collection techniques for both wadeable and non-wadeable waters. Protocols are specified for the most common sample types including bacteriological, routine, nutrient, metal, NPDES extractables and volatiles and pesticides/PCBs. General protocols are also described for the specifications and accurate use of various devices associated with chemical and bacteriological surveys including multi-parameter probes, continuous monitoring probes, automatic samplers, and flow meters. To ensure the integrity of all samples, protocols concerning sample custody, chain of custody, and quality control samples are also included in this document.

I.C. Definitions and Acronyms

Ambient Monitoring: Routine sampling and evaluation of receiving waters not necessarily associated with periodic disturbance.

Bias: Consistent deviation of measured values from the true value, caused by systematic errors in a procedure.

Composite Sample: Composite samples can be time or flow proportional. Time integrated composite samples are collected over time, either by continuous sampling or mixing discrete samples. Flow proportional composite samples are composed of a number of samples sized relative to flow. Composite samples may also be combined manually by collecting grab samples at various intervals in a waterbody.

Convex meniscus: The curved upper surface of a liquid column that is convex when the containing walls are wetted by the liquid.

Ecological Subregion (or subecoregion): A smaller area that has been delineated within an ecoregion that has even more homogenous characteristics than does the original ecoregion. There are 25 (Level IV) ecological subregions in Tennessee.

Ecoregion: A relatively homogenous area defined by similarity of climate, landform, soil, potential natural vegetation, hydrology, and other ecologically relevant variables. There are eight (Level III) ecoregions in Tennessee.

Ecoregion Reference: Least impacted waters within an ecoregion that have been monitored to establish a baseline to which alterations of other waters can be compared.

Grab Sample: Grab samples consist of either a single discrete sample or individual samples collected at a specific place and time or over as short a time as possible that represents the composition of the sample only at that time and place.

Holding Time: Maximum amount of time a sample may be stored before analysis as required in 40 CFR, Part 136

Kemmerer: A type of discrete depth sampler. A Kemmerer is composed of a cylinder with stoppers on each end that can be closed remotely with the use of a weighted messenger.

Lentic waters: Contained waters with restricted flows including lakes, ponds, wetlands and reservoirs.

Lotic waters: Flowing waters including rivers and streams.

Matrix: Refers to the type of material that makes up the sample.

Organic-free Reagent-Grade Water (Type I): Potable water that has been distilled then passed through a standard deionizing resin column and filtered through activated carbon. The water must meet analyte free water criteria, specific to the parameter being analyzed, and have no detectable metals, inorganic compounds, pesticides, herbicides, or extractable or volatile organic compounds. This water may be obtained from the TDH Environmental Central or Branch Laboratories. Organic-free reagent-grade water should not be stored more than 28 days.

Primary Sampler: Refers to the sampler responsible for the sample.

Quality Assurance (QA): Includes quality control functions and involves a totally integrated program for ensuring the reliability of all monitoring and all measurement data; the process of management review and oversight at the planning, implementation and completion stages of date collection activities. Its goal is to assure the data provided are of high quality and scientifically defensible.

Quality Control (QC): Refers to routine application of procedures for obtaining prescribed standards of performance in the monitoring and measurement process; focuses on detailed technical activities needed to achieve data of the quality specified by data quality objectives. QC is implemented at the field or bench level.

Reference Database: Biological, chemical, physical, and bacteriological data from ecoregion reference sites.

Recommend: Advise as the best course of action. Synonyms: optional, may, should.

Require: Obligatory or necessary. Synonyms: must or shall.

Split Sample: A sample that has been portioned into two or more containers from a single sample container or sample mixing container. This type of sample is used to measure sample handling variability and to compare analytical methods.

Thalweg: A line representing the greatest surface flow and deepest part of a channel.

Trace Metals: Low-level metal analyses requiring ultra-clean sample collection and laboratory analyses generally reported in the low parts per trillion range.

Wadeable: Rivers and streams less than 4 feet deep unless there is a dangerous current or other extreme conditions deemed as unsafe.

Watershed: The area that drains to a particular body of water or common point.

Acronyms

ASTM	American Society of Testing and Materials
ATCC	American Type Culture Collection
BTEX	Benzene, Toluene, Ethylbenzene, Xylene
CFR	Code of Federal Regulations
CFS	Cubic Feet/Second
D.O.	Dissolved Oxygen
DQOs	Data Quality Objectives
EFO	Environmental Field Office
ES	Environmental Specialist
EPA	Environmental Protection Agency
EPH	Extractable Petroleum Hydrocarbons
Ft/S	Feet per Second
GPS	Global Positioning System
GRO	Gasoline Range Organics
LDB	Left Descending Bank
LEW	Left Edge of Water
LIMS	Laboratory Information Management System
MDL	Minimum Detection Limit
MPN	Most Probable Number
MSDS	Material Safety Data Sheet
N	Questionable Data
NCR	No Carbon Required
NPDES	National Pollutant Discharge Elimination System
OSHA	Occupational Safety and Health Administration
PAS	Planning and Standards Section
PCBs	Polychlorinated Biphenyls
PFD	Personal Floatation Device
QAPPs	Quality Assurance Project Plans
QA/QC	Quality Assurance/Quality Control
RDB	Right Descending Bank
REW	Right Edge of Water
SOP	Standard Operating Procedure
SQSH	Semi-Quantitative Single Habitat
TAL	Target Analyte List
TCLP	Toxicity Characteristic Leeching Procedure
TDEC	Tennessee Department of Environment and Conservation
TDH	Tennessee Department of Health
TMDL	Total Maximum Daily Loading
TOC	Total Organic Carbon
TOPO	Topographic Map
TWRA	Tennessee Wildlife Resources Agency
USGS	United States Geological Survey
WMS	Watershed Management Section
WPC	Water Pollution Control

I.D. Health and Safety Warnings

Adapted from Klemm et al., 1990

1. Know how to swim and/or use a PFD when entering the water.

2. Always waders with a belt to prevent them from filling with water in case of a fall. If it is necessary to wade in high velocity and high flow streams it is advisable to wear a PFD.

3. Follow Tennessee boating laws and regulation. Information is available through the Tennessee Wildlife Resources Agency (TWRA). PFDs are required when operating a boat.

4. Be vigilant, especially in turbid streams to avoid broken glass, beaver traps or other hazardous objects that may lie out of sight on the bottom. Heavy wading boots should be worn in these situations.

5. Keep first aid supplies in the EFO and in the field at all times. Training in basic first aid and cardio-pulmonary resuscitation is strongly recommended.

6. Any person allergic to bee stings or other insect bites should have needed medications in the event of an allergic reaction and instruct others in the party on how to use the allergy kit.

7. Always handle acid preservatives under a properly installed and operating fume hood. Check to be certain the fume hood is functioning properly. Always wear personnel protective equipment (gloves, safety glasses, and lab coat) when handling preservatives. Know the location and how to use eyewash and shower stations.

8. Carry communication equipment in the field in case of an emergency.

9. Keep an employee file in the field office that contains emergency contacts and physician's name for each employee. Carry a list of emergency contact numbers for the sample area. Know the location of hospitals and law enforcement stations in the area.

10. Consider all surface waters a potential health hazard due to toxic substances or pathogens. Minimize exposure as much as possible and avoid splashing. Do not eat, drink, smoke, apply cosmetics or handle contact lenses while collecting samples. Wearing gloves limits exposure to potential health hazards. Clean exposed body parts (face, hands, and arms) immediately after contact with these waters. Carry phosphate-free soap and an adequate supply of clean water, disinfectant wipes, and/or waterless sanitizer.

11. If working in water known or suspected to contain human wastes, EPA recommends immunization against tetanus, hepatitis, and typhoid fever (Table 1). Beginning August 2002, the TDH has denied WPC request for such vaccinations at the employee clinic.

However, this does not preclude employees from contacting their physician and requesting vaccinations they believe are appropriate.

Table 1: EPA Recommended Vaccinations

Vaccination	No. of shots	Interval	Booster
Hepatitis B	3	0, 1, 6 months	NA
Tetanus	1	NA	10 years
Polio	1, if childhood series completed	NA	20 years
Typhoid	2	1 month	3 years

12. Try to avoid working alone in the field. When working alone, make sure your supervisor or their designee knows where you are and when you are expected to return. Check in periodically.

13. Material Safety Data Sheets (MSDS) are available for all preservatives and other hazardous chemicals. Everyone working with these agents or handling preserved bottles must be familiar with the location and contents of the MSDS. Notify supervisor if MSDS sheets cannot be located.

14. Powder-free nitrile gloves must worn when handling blank water or collecting metal samples. Either powder-free nitrile or latex gloves can be used for other sampling. Latex gloves may provide more protection from pathogens.

15. Check to make sure lids are tightly fastened and pre-preserved bottles are stored in an upright position.

16. In very hot weather, store pre-preserved bottles on ice to avoid acid vaporization and a potentially hazardous situation when opening a swollen bottle. Pressurized bottles can spray acid when opened and could cause acid burns on eyes and exposed skin.

17. When traveling in a state vehicle always wear a seat belt and follow all Tennessee Department of Safety and Motor Vehicle Management rules.

19. In the event of a life-threatening emergency, go to the nearest hospital. Call for emergency assistance if moving the injured person is likely to inflict further injury. If a non-life

threatening injury occurs on the job, seek medical assistance from the authorized state worker's compensation network. A current list of providers may be found on the State Treasurer's homepage under Workers Compensation, Provider Directory at www.tn.gov/treasury. Always complete and file an accident report if medical assistance is provided for a work related injury.

20. If water conditions necessitate that water samples be collected from a bridge, appropriate safety precautions must be considered and are recommended to ensure the safety of personnel as well as drivers. OSHA's *Manual on Uniform Traffic Control Devices* (1993) provides safety instructions for work on and near roadways. Since chemical sampling events occupy a location for less than one hour (Short Duration-Work), OSHA allows for simplified traffic control procedures. Specialized safety equipment should be used to warn oncoming traffic of staff present on the bridge.

    - Orange safety vest for every member of the sampling team
    - At least three orange traffic cones or traffic warning triangles
    - Magnetic amber strobe light (and spare batteries)

    Use extreme caution when working on the bridge and around traffic. All personnel involved in sampling from the bridge should wear an orange safety vest while working from the bridge. If possible, park the vehicle out of the lane of traffic before crossing the bridge on the upstream side. Set the parking brake, turn on the emergency lights and place the magnetic strobe light (turned on) on the roof of the vehicle where it is most visible to on-coming traffic.

    Place at least two orange traffic cones in a diagonal line from outside edge of the shoulder behind the vehicle toward the white line for the lane of traffic. Place the final cone on the bridge at the beginning of the work area. Avoid inhibiting the flow of traffic. Spend as little time on the bridge as possible. To avoid falling off the bridge, try to avoid leaning on or climbing over railings.

21. When entering or crossing private property, it is advised that you obtain permission from the landowner beforehand in order to avoid confrontation. If approached by someone representing law enforcement, it may be a good idea to show them your state I.D. and also ask to see their I.D. or badge. The Tennessee Highway Patrol can be reached by dialing *THP (*847) from you mobile phone. The phone numbers for the THP district headquarters are listed below.

Knoxville:	(865) 594-5793	Chattanooga:	(423) 634-6898
Nashville:	(615) 741-3181	Memphis:	(901) 543-6256
Fall Branch:	(423) 348-6144	Cookeville:	(931) 528-8496
Lawrenceburg:	(931) 766-1425	Jackson:	(731) 423-6635

I.E. Cautions

1. Avoid sampling bias by following the procedures outlined in this QSSOP. Document any deviations.

2. Avoid cross contamination of samples. Always use new certified-clean bottles for chemical samples and sterilized bottles for bacteriological samples. It is recommended that samples be placed in colorless plastic zip-type bags to avoid cross contamination in the cooler.

3. Use the standardized station ID naming protocol for all surface water samples (Protocol B). Continue to use established naming protocols ecoregion and headwater reference sites. Check water quality database to make sure a station has not already been established with a different station ID. Notify PAS of any discrepancies. Make sure the station ID is included on all paperwork and tags associated with the sample.

4. Measure stream length from mouth to headwaters. When measuring embayments, measure length of original channel from confluence with the original channel of the main stem. Use GIS (preferred) or map wheel at the 1:2400 (7.5 minute) scale to measure stream miles. When using GIS use the ArcView measuring tool, do not use the Reach File INdex of the NHD flowline layer which measures in straight lines. Do not use the TDEC on-line assessment map measuring tool as it is inaccurate due to rounding errors. The USGS site http://water.usgs.gov/osw/streamstats/tennessee.html may be used.

5. To avoid errors, it is recommended to calibrate all meters at the beginning of each day (unless overnight travel is required). The meters should minimally be calibrated once a week. Perform a drift check at the end of each day (or on return to office if overnight sampling). If the meter calibration is off by more than 0.2 units for pH, temperature, or D.O. when measured in mg/L, by more than 10% for conductivity, or 10% D.O. when measured in % saturation, precede all readings between the initial calibration and the drift check with an N (questionable data) on the stream survey sheet and on any Chemical Request Forms turned in at the TDH Environmental lab. If sample request forms have already been submitted, notify the Planning and Standards Section of questionable readings in writing (e-mail or fax).

6. Record all time in a 24-hour (military) clock format.

7. Write all dates in mm/dd/yy or mm/dd/yyyy format. (For example, March 2, 2003 would be 03/02/03 or 03/02/2003.)

8. Record all distance measurements in meters, with the exception of flow. Flow is measured in cubic feet per second (cfs). If instrument or tape measure is in different units, record the actual readings and convert to appropriate units before reporting results.

9. Use GPS to confirm location at site. Record latitude and longitude in decimal degrees.

10. Set all meters to measure temperature in degrees centigrade (^{o}C). Record all temperature readings in degrees centigrade.

11. If an error is made in any documentation, draw a single line through the error, so that it is readable and write the correction above. Date and initial the correction. Do not white out or place several lines through errors.

12. If at all possible chemical and biological (SQSH) samples should be collected on the same day (required for CADDIS analysis). It is preferred that the chemical and biological (SQSH) sampling of a single station not be separated by more than four weeks.

13. Check water quality database current stations table before assigning station names to make sure a name has not already been assigned to the site by another sampling team or agency. Check station Ids to verify names follow logical progression from downstream to upstream.

I.F. Interferences

1. Document all deviations from protocol.

2. Unless the study design requires flood or post-flood sampling, avoid sampling in flooded conditions or immediately after a flood.

3. Avoid sampling streams reduced to isolated pools unless deemed necessary for study objectives.

4. Flag dissolved oxygen when measured in mg/L, pH, temperature and conductivity readings with an N (questionable data) if post-trip drift checks show meter calibrations to be off by more than 0.2 units (or 10% for conductivity and dissolved oxygen when measured in % saturation). All readings taken between initial calibration and drift check should be flagged.

5. Properly clean any reusable sample contact equipment such as Nalgene® bucket, Teflon Kemmerer or bailer, or composite samplers between uses. See Section I.H and I.I, Protocol E for cleaning procedures for sampling equipment.

6. Do not smoke while collecting samples.

7. It is required that powder-free nitrile gloves be worn when obtaining blank source water, preparing QC blanks, or collecting metal samples. Either powder-free nitrile or latex gloves can be used for other sampling. Latex gloves may provide more protection from pathogens.

8. Before collecting nutrient samples, wash hands with phosphate-free soap.

9. When collecting samples, avoid contaminating samples by using lotions, insecticides, sunscreens, or other chemicals.

10. Atmospheric metals from automobile exhaust, cigarette smoke, bridges, wires or poles can also contaminate samples. Collect samples at least 100 yards upstream of bridges, wires, poles, or roads when possible.

11. To ensure a representative sample and/or to avoid contamination, do not sample from banks, shorelines, or docks. If thalweg cannot be reached due to depth, collect sample using boat or from bridge. If necessary, sample may be collected outside of thalweg as long as it is within the main current.

I.G. Personnel Qualifications and Training

Tennessee Civil Service Titles: Biologist, Environmental Specialist, Environmental Protection Specialist, Environmental Program Manager, Environmental Field Office Manager, Chemist or trained co-op/intern. For the purpose of this report, all position titles will be referred to as sampler or staff.

Minimum Education Requirements: B.S. in any science, engineering, or B.S. candidate under the supervision of experienced staff.

Minimum experience: There is no substitute for field experience. It is recommended that all staff have at least six months of field experience before selecting sampling sites. For on the job training, new employees should accompany experienced staff to as many different studies and sampling situations as possible. During this training period, the new employees are encouraged to perform all tasks involved in sample collection under the supervision of an experienced staff member.

Quality Team Members are to be selected by EFO WPC managers to oversee quality control and training and help ensure the protocols outlined in this document are properly followed. Quality Team Leader is a centralized chemical and bacteriological QC coordinator. Quality Team Leader and Members should be experienced water quality personnel who have been trained in water quality sampling and quality control (Section II.A).

Sampler Expertise: Use and calibration of standard water quality monitoring meters (DO, pH, conductivity, and temperature meters), flow meters and wading rods, subsurface sampling devices, discrete depth sampling devices (Kemmerer and peristaltic pump), composite samplers, GPS, and boats.

Sampler Training:

Protocols outlined in this SOP

- Station selection and assigning station identification numbers
- Sample collection procedures, equipment cleaning, and use for wadeable and non-wadeable surface water collections
- Cleaning, maintenance, and use of automatic samplers
- Completion of sample identification tags, sample request forms and chain-of-custody
- TDH laboratory requirements for sample submission
- Calibration and maintenance of instantaneous and continuous water parameter probes
- Calibration and maintenance of flow meters
- Use of map wheels, topographic maps, GPS units, cameras and other equipment
- Bacteriological analyses

Quality System Requirements, Quality Assurance Project Plan

Boats

Health and Safety

I.H. Equipment and Supplies

Prior to any sampling trip, gather and inspect all necessary gear. Replace or repair any damaged equipment. Order sample bottles at least two weeks before they are needed (Appendix A). Calibrate all meters prior to the sampling trip (minimally once a week if used). Upon return from a trip, take care of any equipment repairs or replacements immediately. Necessary equipment will vary per project, but the following is a standardized list.

1. General Field Equipment

- Waders
- External sample tags
- Sample request forms
- Field Flow Sheet or field book
- Topographic maps (USGS quadrangle maps) may also be referred to as topos or quads
- Tennessee Atlas and Gazetteer
- GPS unit for recording latitude and longitude in decimal degrees at new stations
- Cell Phone or other communication device (recommended)
- Calibrated dissolved oxygen meter
- Calibrated pH meter
- Calibrated conductivity meter
- Temperature meter or thermometer in ^{o}C
- Field barometer if needed for on-site DO calibration
- Repair kit for water parameter meters (DO replacement membrane for multi-day trips)
- Calibrated flow meter, wading rod (10^{th} of feet markings), and sensor cable
- Measuring or surveyors tape (50, 100, 200 feet) in 10^{th} of feet markings and rope long enough to span the river or stream
- Stakes (minimum 3), clamps (minimum 4), and hammer or other means of securing measuring tape
- Flow meter manual and screwdriver
- Spare batteries for all meters, flashlights, GPS and camera.
- Waterproof pens (Sharpies®), pencils and black ballpoint ink pens (not roller-ball)
- Flashlights in case detained after dark
- Duct tape for emergency repairs
- First aid kit
- Watch
- Map wheel (for calculating stream miles if new stations are to be assigned in field and GIS is not available)
- Disposable beakers if needed for shallow stream sample collection
- Sample bottles + 10% QC bottles, extra bottles
- 1 gallon plastic zip-type bags (recommended)
- Powder-free nitrile gloves (Required for when preparing QC blanks and metal samples). Either powder-free nitrile or latex gloves can be used for other sampling. Latex gloves may provide more protection from pathogens.

- ☐ Shoulder length powder-free nitrile gloves (if collecting trace metals or low-level mercury)
- ☐ State ID badge
- ☐ Ice stored in coolers (ice may be placed in plastic bags for easier handling then dumped over bottle after the last samples are collected)
- ☐ Clean coolers
- ☐ Temperature blank bottle (1/cooler)
- ☐ Custody seals if required (see Section I.I, Protocol C).
- ☐ Digital camera, for documenting potential pollution sources and waterbody conditions
- ☐ Graduated Cylinder if needed for measuring adequate sample amounts.

a. Additional Items Needed for Non-Wadeable Sites

- ☐ Bacteriological sampling: swing sampler or other appropriate bottle holder or sterile sampling device
- ☐ Inorganic chemical sampling: Teflon® or High Density Polyethylene (Nalgene®) bucket attached to a rope, Teflon® Kemmerer, bailer, or peristaltic pump
- ☐ Organic chemical sampling: stainless steel bucket (attached to a rope), Kemmerer, or bailer
- ☐ Stop watch or watch with second hand for estimating flow.

If Using a Boat

- ☐ Boat with appropriate safety equipment, paddles, and PFDs. Comply with TWRA regulations.

b. Additional Items Needed for Field Cleaning Equipment

- ☐ Phosphate-free laboratory-grade detergent
- ☐ Tap water stored in a clean covered tank, or squeeze bottle
- ☐ Deionized water stored in a clean covered tank or squeeze bottle

c. Additional Items Needed for Diurnal Monitoring

- ☐ Continuous monitoring probe
- ☐ Sensor cable
- ☐ Laptop computer programmed for the continuous monitoring multi-probe
- ☐ Field manual for the probe and software
- ☐ Stainless steel cable or chain
- ☐ Crimps
- ☐ Crimp and wire cutter pliers
- ☐ Nylon cable
- ☐ Appropriate anchoring and/or flotation device such as:
  - Rebar and hammer (firm substrate)

- Wooden board (soft sand/silt substrate)
- Concrete block (soft sand/silt substrate)
- Float with probe holder to suspend the probe in the water column and a weight to hold it in place (deeper waters)

d. Additional Items Needed for Automatic Sampling

- ڤ Automatic sampler
- ڤ New Silastic® or equal tubing
- ڤ New Teflon® or Tygron® or equal tubing
- ڤ Clamps and/or electrical ties
- ڤ Spare batteries
- ڤ Ice

2. Sample Container Acquisition

At least two weeks (preferably one month) prior to needing sample bottles for routine scheduled sampling place a bottle order (Appendix A) with the appropriate TDH Environmental Lab and notify the environmental and microbiological sample coordinators of when samples will be arriving (Table 2). Remember to include an adequate number of bottles for quality assurance testing of at least 10% of planned samples. TDH Environmental Laboratory has requested, "all samples submitted for analysis should be properly collected in bottles furnished and prepared by the Environmental Laboratories" (Tennessee Department of Health, 2001).

When picking up a bottle order, make sure the correct numbers of bottles are present and the lids on the pre-preserved bottles are tight to avoid preservative leakage and possible acid burns. Always keep numerous spare bottles on hand for unscheduled complaint and emergency sampling. According to TDH laboratory, pre-preserved sampling containers may be stored for up to one year. Pre-preserved bottles should have the date of preservation attached to them.

Note: If using another TDEC contract laboratory, contact the specific lab about obtaining bottles. Make sure that minimum required detection limits (Appendix B) will be met and results will be sent to PAS.

Table 2: TDH Environmental Laboratory Contact Information

Nashville Central Laboratory 630 Hart Lane Nashville, TN 37247	Knoxville Regional Laboratory 1522 Cherokee Trail Knoxville, TN 37920	Jackson Regional Laboratory 295 Summar Dr. Jackson, TN 38301
Environmental Sample Coordinator: (615) 262-6342	Sample Coordinator: (865) 549-5279	Sample Coordinator: (731) 426-0685
Microbiological Sample Coordinator: (615) 262-6371		
After Hours Emergency Number (all labs): (615) 262-6300		

The TDH Environmental Laboratory will continue to provide sample request forms, bacteriological bottles and other specially preserved bottles not included on the sample container request form such as cyanide and sulfide. To obtain these items, contact:

Leo Barrociere
(615) 262-6342
leo.barrociere@tn.gov

Dr. Pramod K. Singh
(615) 262-6341
pramod.singh@tn.gov

The following field biology and additional sample containers will be available directly from Laboratory Services:

30 mL wide mouth bottle (Inventory # 200-0190) - biorecons
1/2 gallon wide mouth jar (Inventory # 200-0810) - SQSH
125 mL amber wide-mouth sample bottle – periphyton
Cup, sediment 16 oz, ENV (Inventory # 200-0560).

NOTE: the 16 oz sediment cups are used by DOE Oversight for particle sizing, sediment TOC, sediment Rad, sediment metals, mercury and cyanide.

Contact: Dr. Bob Read
(615) 262-6302
bob.read@tn.gov

Organic Chemistry will continue to provide the sample containers required for 1,4-Dioxane analysis.

Contacts: Cathie Ayers
(615) 262-6336
cathie.b.ayers@tn.gov

Dr. Luz Castro-Maderal
(615) 262-6395
luz.maderal@tn.g

3. Sample container descriptions

a. Bacteriological Collection Bottles

Collect bacteriological samples in sterile polypropylene screw-cap bottles pre-preserved with sodium thiosulfate and EDTA. These bottles may be obtained from TDH Environmental Laboratory or other TDEC contract laboratories.

Bacteriological bottles should minimally be labeled with a preparation date. Some laboratories also label bottles with an expiration date. Bacteriological bottles have a one-year shelf life from the date of preparation. Do not use expired bottles. To ensure an adequate volume of water is available for analyses, collect two 250-milliliters bottles for each sample. The two bottles are considered one sample and should be labeled with the same collection time. If the sample will be analyzed only for *E. Coli*, and no other pathogens, collect one 250-milliliter bottle. See protocol C for complete instructions on collecting bacteriological samples from surface waters.

b. Inorganic Collection Bottles

Collect inorganic samples in the proper sample bottle with the appropriate preservative (Table 3). Pre-preserved sample containers may be stored and used for one year. These bottles should minimally be labeled with a preparation date. Only use certified pre-cleaned single-use plastic bottles for routine, nutrient, metal, mercury, cyanide, boron, and TCLP sampling. Only use certified pre-cleaned single-use amber glass vials for TOC sampling. Oil and grease, phenols, sulfides, and flash point samples are collected in properly cleaned (Section I.H) glass bottles.

See Protocol C for complete instructions on collection of inorganic samples. Special precautions are given for the collection of trace metal and low-level mercury samples. Protocols D, E, and F specify collection techniques for wadeable and non-wadeable waterbodies.

c. Organic Collection Bottles

The most commonly requested organic analyses are NPDES extractable and volatiles, and pesticides/PCBs (Table 4). All organic samples are collected into properly cleaned amber bottles or vials. Pre-preserved bottles should minimally be labeled with a preparation date and preferably an expiration date. See Protocol C for complete instructions on collection of volatile samples. If analyses other than those listed here are needed, contact the organic section of TDH Environmental Laboratory or other TDEC contract laboratory for the appropriate sample container and sampling method.

Table 3: Inorganic Sample Bottles and Preservatives

Sample Type	Bottle Type	Preservative
Routine	1 liter or 1 gallon plastic	None
Nutrient	500 mL plastic	1 mL sulfuric acid (H_2SO_4) (Reagent-Grade)
Metals	1 liter plastic	5 mL 70% nitric acid (HNO_3) (Trace Metal Grade)
Mercury*	1 liter Metals (same bottle as above) or 500 mL plastic*	2.5 mL 70% nitric acid (HNO_3) (Trace Metal Grade)
Cyanide	1 liter plastic	pH>12; 5 mL of 50% sodium hydroxide (NaOH) at collection. If KI paper indicates chlorine, add 0.6g ascorbic acid ($C_6H_8O_6$) before adding NaOH. If sulfides are detected by lead acetate paper, add 1g of Cadmium Chloride ($CdCl_2$) after adding NaOH.
Oil & Grease	1 liter glass, wide mouth with Teflon® lined lid	2 mL sulfuric acid (H_2SO_4) (Reagent-Grade)
Phenols, total	1 liter glass, amber with Teflon® lined lid	2 mL sulfuric acid (H_2SO_4) (Reagent-Grade)
Sulfide	500 mL glass	2 mL zinc acetate (ZnAc) in the lab. 5 mL 50% sodium hydroxide (NaOH) in field.
Boron	125 mL plastic	0.75 mL hydrochloric acid (HCl) (Reagent-Grade)
Flash Point (Ignitability)	16-ounce glass jar with Teflon® lined lid.	None
Toxicity Characteristic Leaching Procedure (TCLP)	16-ounce glass jar	None
Total Organic Carbon (TOC)	Three 40 mL amber glass vials. A fourth vial is required for QC at one site for each sampling run. (See Section I.I, Protocol C, pg 12)	0.1 mL phosphoric acid (H_3PO_4) (Reagent-Grade)

* 500 mL mercury bottles only need to be used for samples delivered to the Knoxville Lab or if mercury is the only metal that is being analyzed.

Table 4: Organic Sample Bottles and Preservatives

Test	Container	Preservative
Base/Neutral/Acids Extractables		
NPDES Extractables	One (1) - 1-gallon amber bottle, acetone-rinsed, with Teflon®-lined cap	None
Pesticides/PCBs		
Target Analyte List (TAL) Extractables		
Nitrobodies (suspected explosives)		
Semivolatiles		
Volatiles and Petroleum Hydrocarbons		
NPDES Volatiles	Five (5) - 40-mL amber vials with Teflon®-lined septa caps, no headspace	1:1 Hydrochloric Acid (HCl) (Reagent-Grade)
Target Analyte List (TAL) Volatiles		
Benzene, Toluene, Ethylbenzene, Xylenes (BTEX)	Five (5) – 40-mL amber vials with Teflon® lined septa caps, no headspace	1:1 Hydrochloric Acid (HCl) (Reagent-Grade)
Gasoline Range Organics (GRO)		
Extractable Petroleum Hydrocarbons (EPH)	One (1) – 1-gallon amber bottle with Teflon® lined lid	1:1 Hydrochloric Acid (HCl) (Reagent-Grade)

4. Equipment Cleaning

a. Wader Cleaning Procedure

Rinse mud and debris from waders between sampling sites to avoid cross-contamination. Mud may be rinsed from waders in creek or river before leaving the site.

b. Cooler Cleaning Procedure

To avoid cross-contamination between samples, clean all sample storage coolers between uses with hot phosphate-free laboratory grade soapy water and thoroughly rinse with hot tap water. Allow coolers to air-dry with the lid open. Once dry, store in a clean area with lids closed to avoid contamination from air-born particles. If coolers will be reused immediately, they do not need to be air dried after being washed and rinsed.

c. Field Parameter Bucket Cleaning Procedure

If a bucket will only be used for the measurement of field parameters, rinse it once with surface water from the site before the field parameter sample is collected. Likewise, rinse the bucket once with tap water after the sample is collected. When the bucket becomes visibly dirty, muddy, or oily, clean the bucket following sample equipment cleaning procedure (Section I.I., Protocol C). Multiple clean buckets can be taken on a sample run so that one bucket doesn't have to be washed between each site.

d. Sampling Equipment Cleaning Procedure

Clean all reusable equipment that comes in direct contact with sample water, such as Kemmerer, properly constructed sample bucket (Protocol F), or automatic sampler, between uses. It is preferable to arrange the sampling schedule so the equipment can be cleaned in the controlled environment of the EFO lab. If it is not possible to return to the EFO between sampling stations, the field cleaning procedure in Section I.I. Protocol C must be followed. Document any deviation from this procedure.

(1). Soap Wash – Wash the equipment with a phosphate-free laboratory detergent, such as Alconox® or Sparkleen® and hot tap water. Use a clean scrub pad to remove any surface film or particulate matter. Store the soap in a clean container and pour directly from the container.

(2). Tap Water Rinse – Rinse the equipment thoroughly with hot tap water.

(3). Deionized Water Rinse – Rinse equipment at least twice with deionized water using either a squeeze bottle or the outlet hose from the deionizing system. If the sampling equipment is being cleaned for the collection of organic samples, the rinse water must be organic-free reagent-grade water dispensed from a Teflon® squeeze bottle or a Teflon® outlet hose.

(4). Air-Dry – Allow opened equipment to air-dry on a clean surface before storage in a clean area.

e. Glassware Cleaning Procedure

Clean all glassware, such as pipettes, glass sample containers or any piece of equipment that will directly or indirectly contact sample water or preservative, between uses. Document any deviation from this procedure. Provide MSDS data sheets for all solvents and acids used in this procedure. To avoid equipment contamination and personal injury, wear personal protective gear when cleaning sample contact equipment. Wear safety glasses, powder-free nitrile gloves, and a clean lab coat or neoprene apron while cleaning the equipment. Do not eat, drink, smoke or have any hand to mouth contact while cleaning the equipment. Conduct all solvent rinses under a fume hood and never in a closed room.

(1). Soap Wash – Wash the equipment with a phosphate-free laboratory detergent such as Alconox® or Sparkleen® and hot tap water. Use a clean scrub pad to remove any surface film or particulate matter. Store the soap in a clean container and pour directly from the container.

(2). Tap Water Rinse – Rinse the glassware thoroughly with hot tap water.

(3). Nitric Acid Solution (10%) – Rinse glassware using a plastic squeeze bottle with a mixture of 10% nitric acid and 90% deionized water. Store Nitric Acid in its original labeled container until use. A 10% Hydrochloric Acid (HCl) rinse should be used for glassware or equipment intended for nutrient analyses. If a different acid rinse is used, document the acid used.

(4). Deionized Water Rinse – Rinse glassware thoroughly with deionized water using either a squeeze bottle or the outlet hose from the deionizing system. If the sampling equipment is being cleaned for the collection of organic samples, the rinse water must be organic-free reagent-grade water and the dispenser a Teflon® squeeze bottle or a Teflon® outlet hose.

(5). Solvent Rinse – Pesticide-grade isopropanol is the preferred final rinse of glassware. Store isopropanol in its original container until use and dispense using a Teflon® squeeze bottle. The final rinse for organic glassware is acetone. Acetone is a likely source of contamination if it is not allowed to completely evaporate. If acetone is used as a solvent rinse, it must be allowed to completely air-dry before glassware is used. Document the solvent used if anything besides pesticide-grade isopropanol is the final rinse.

(6). Air-dry – Allow equipment to air-dry on a clean surface and store glassware in a clean area.

I.I. Procedures

Protocol A - Selection of Sample Type and Site Location

Sampler
Central Office Coordinator

1. Sample Analyses Selection

The majority of samples are used for multiple purposes, regardless of the primary sampling objective. For example, TMDL samples will also be used for assessments, criteria development and ecoregion calibration. Therefore, all samples must have the same confidence in the accuracy of the sample quality and analyses. The study objective will determine what parameters need to be analyzed from a given sample (Table 5). The parameters in turn determine the types of samples that need to be collected (Appendix B). Table 6 provides information on bottle types needed for the most common monitoring activities.

Consult WPC's annual Tennessee Water Quality Monitoring and Assessment Program Plan and the Quality Assurance Project Plan for 106 monitoring for specific details on planned sampling objectives. Samples collected for different purposes will have different sampling needs. Table 6 provides information on sample needs for some routine sampling activities.

a. Ecoregion samples require specific analyses.

b. Waters on the 303(d) List must minimally be sampled every watershed cycle, for the cause that they were placed on the 303(d).

c. Consult the TMDL monitoring guidelines (Appendix C) for general TMDL monitoring requirements. Contact the TMDL manager prior to monitoring to determine specific monitoring stations, sampling periods and data needs.

d. Watershed sampling needs will vary by site.

e. Compliance or enforcement monitoring should be done according to permit specifications.

f. In non-scheduled monitoring such as complaints, spills, and other emergencies, the sampling objective will determine what parameters need to be analyzed. For assistance with determining what analyses are needed, consult the EFO WPC Manager or other experienced staff for site-by-site analyses determinations.

Table 5: Recommended Parameter List for Surface Water Samples

Parameter	TMDLs				Ref. Sites ECO and FECO*	303(d)	Long Term Trend Stations	Watershed Sites	QC Blanks
	Metals †/pH	DO	Nutrients	Pathogens					
Acidity, Total	X (pH)								
Alkalinity, Total	X (pH)				X	O	X	O	X
Aluminum, Al						O	X	O	**
Ammonia Nitrogen as N		X	X		X	O	X	O	X
Arsenic, As					X	O	X	O	X
Cadmium, Cd	X†				X	O	X	O	X
Chromium, Cr	X†				X	O	X	O	X
$CBOD_5$		X				O	X	O	
Color, Apparent					X		X		
Color, True					X		X		
Conductivity (field)	X	X	X	X	X	X	X	X	
Copper, Cu	X†				X	O	X	O	X
Cyanide, Cy							X		
Dissolved Oxygen (field)	X	X	X	X	X	X	X	X	
Diurnal DO		X	X						
E. Coli				X	X	O	X	O	X
Fecal Coliform				X	X	O	X	O	**
Flow	X	X	X	R	X	O	X	O	
Iron, Fe					X	O	X	O	X
Lead, Pb	X†				X	O	X	O	X
Manganese, Mn					X	O	X	O	X
Mercury, Hg						O	X	O	**
Nickel, Ni	X†					O	X	O	**
Nitrate + Nitrite		X	X		X	O	X	O	X
pH (field)	X	X	X	X	X	X	X	X	
Residue, Dissolved					X	O	X	O	
Residue, Settleable						O	X	O	
Residue, Suspended	X		X	X	X	O	X	O	
Residue, Total						O	X	O	
Selenium, Se	X				X	O	X	O	X
Sulfates					X (69d & 68a)	O	X	O	X
Temperature (field)	X	X	X	X	X	X	X	X	
Total Hardness	X				X	O	X	O	X
Total Kjeldahl Nitrogen		X	X		X	O	X	O	X
Total Organic Carbon	X		X		X	O	X	O	X
Total Phosphorus (Total Phosphate)		X	X		X	O	X	O	X
Turbidity			X	X	X	O	X	O	X
Zinc, Zn	X†				X	O	X	O	X
Biorecon					X	X		X	
SQSH					X	O (replace biorecon)		O (replace biorecon)	
Habitat Assessment					X	X		X	

Optional (O) – Not collected unless the waterbody has been previously assessed as impacted by that substance or if there are known or probable sources of the substance. R – Recommended if time allows. † – Sample for pollutant on 303(d) List.

* These analyses are required for Ecosites and established FECO sites.

** These QC blanks need to be analyzed if parameter is collected within the QC set.

Table 6: Sample Containers for Surface Water Samples

Sample Container	Collect for Ambient	Collect for Reference sites (ECO & FECO)	Collect for Watershed
1-gallon or 1-liter Certified Clean single-use Routine	X	X	X
Two 250 mL Bacteriological*	X	X	X
1-liter Certified Clean single-use Metal	X	X	X[m]
1-500 mL Certified Clean single-use Nutrient	X	X	X
1-500 mL Certified Clean single-use Mercury**	X		X[m]

* Only 1 bottle is required if *E. coli* is the only analysis needed.

** 500 mL mercury bottles only need to be used for samples delivered to the Knoxville Lab or if mercury is the only metal that is being analyzed, otherwise, the 1-liter Metal bottle is sufficient for mercury analysis.

[m] Metals should not be routinely sampled at watershed sites. Only request analyses if these are a pollutant of concern.

Due to changes in water quality standards, *E. coli* is the preferred analysis for bacteriological sampling. If the bacteriological sample is collected for TMDL development, check with the TMDL manager for any needed additional analyses. Unless required by study objectives, avoid collecting bacteriological samples during or immediately after storm events.

Changes to criteria have reduced the number of required samples for geometric mean calculation from ten to five samples in a 30 consecutive day period. The samples must be taken at least 24 hours apart and not during a rain event. None of the analyses, can be reported as greater than or less than the test detection limit. To determine the likely detection limit needed for proper *E. coli* analysis, check the historical data for existing sites. The "Access" Water Quality Database maintained by WPC houses chemical and bacteriological analyses results. Contact the Planning and Standards Section if assistance is needed in locating or using this database.

After historical *E. coli* readings have been determined for a given sampling station, the sampler should determine if a dilution needs to be requested. If historical *E. coli* readings are greater than 2,419 colonies/100ml, the sampler should request a 1:10 dilution on the sample tags and the sample request form. A 1:100 dilution should be requested if historical readings are greater than 24,190 colonies/100ml. You may also want to request a 1:100 dilution if sewage overflow is observed or suspected. If historical readings are less than 2,419, no dilution is required and no specific notations need to be made on the sample tags or sample request form. If an *E. coli* count in the

Water Quality Database is high and has a denotation of R, for rain event, it is advisable to request both undiluted and 1:100 dilution (Table 7).

When collecting at a new site, the sampler should determine the likely upstream contamination level. If a waterbody is located in an undisturbed area, then an undiluted *E. coli* sample should be sufficient. In an area with likely pathogen sources, such as sewage treatment plant or dairy farms, request a 1:100 dilution. Request both undiluted and diluted (1:100) if the likely pathogen level cannot be determined.

The sampler should call TDH laboratory and request the data if *E. coli* results are not received before the next sampling trip so the correct dilution can be requested on subsequent sampling events. If the sampling objective is to compare the geometric mean to the criterion and any of the five measurements are reported as greater than or less than the count range, then additional samples must be collected until five measurements in a 30-day period, 24 hours apart, are achieved.

Table 7: Detection Limit of *E. coli* Test (Quanti-Tray/2000)

Dilution	Factor	Count Range
None	1X	1 to 2,419
1:10	10X	10 to 24,190
1:100	100X	100 to 241,900

2. Site Selection

Site selection is dependent on the study objectives. After determining the specific objectives of the study and clearly defining what information is needed, select the sampling site in a specific reach of the waterbody. Reconnaissance of the waterway is very important.

Note possible sources of pollution, access points, substrate types, flow characteristics, and other physical characteristics that will need to be considered in selecting the sampling sites. The number and location of sampling stations will vary with each individual study.

Choose a sample location with the greatest degree of cross-sectional homogeneity. The selected sampling location should be well mixed both vertically and horizontally. Since mixing occurs by flow and turbulence, an area downstream of a riffle will insure adequate mixing. In slower moving waters, the mixing zone will extend some distance downstream. It is advisable to avoid confluence areas due to incomplete mixing and changes in flow patterns.

a. For **watershed screenings**, sites are located near the mouth of each tributary if representative of the stream as a whole. If impairment is observed, the watershed is inspected to see if the impairment is consistent. Additional monitoring is not needed if

the impairment is consistent. However, if the impairment originates in a particular area, additional monitoring, if time allows, will help pinpoint the extent of the impairment.

b. For monitoring **point source** pollution, stations are located both upstream and downstream (below the mixing zone) of the source of pollution. Unless the waterbody is extremely small or turbulent, an effluent discharge will usually flow parallel to the bank with limited lateral mixing for some distance. If complete mixing of the discharge does not occur immediately, left bank, mid-channel and right bank stations may be established to determine the extent of possible impact. Stations are established at various distances downstream from the discharge. Collection stations are spaced farther apart going downstream from the pollution source to determine the extent of the recovery zone.

c. For **targeted monitoring**, avoid locations immediately above, or below the confluence of two streams/rivers, or immediately below point/non-point source discharges. Unless the waterbody is very small or extremely turbulent, an inflow will usually hug the stream bank, for some distance from which it was discharged, with little lateral mixing. This may result in very different chemical analyses and an inaccurate assessment of water conditions. This can be avoided by sampling after mixing has occurred.

d. If macroinvertebrate samples are also collected from the same access point, locate sampling stations for chemical, bacteriological, and physical parameters within the same reach (200 meters) as the macroinvertebrate sampling station and assign the same station ID.

e. If a planned sampling location becomes inaccessible due to flooding, closed roads, or other temporary setbacks, if possible, reschedule sampling during normal flow and when the sampling location is accessible. If a site is permanently inaccessible, move the sampling location upstream or downstream to the nearest accessible location.

Protocol B – Assigning Station Identification Numbers

Sampler

Assign station IDs to each site using the following protocol. The station ID will be used to identify the sample and must be included on all associated paperwork, results, tags etc. This number is to be used to identify this site every time it is sampled for any parameter (benthic, fish, bacteria, chemical). If new stations are set up that will also have biological monitoring or a habitat assessment, send the new station information to Planning and Standards as soon as the station location is finalized and before the lab sends results (Usually 30 days). Minimally station information should include station ID, latitude and longitude (in decimal degrees), HUC, ecoregion, stream order and specific location information (such as road crossing) that can be located on a map. If only biological samples will be collected, complete all header information on the stream survey field sheet and send with biological data packet to lab (SQSH) or PAS (biorecon). If the stream is first or second order, drainage area must be indicated.

It is very important that station Ids are assigned consistently with the same location always assigned the same ID regardless of the sample collection type, purpose, samplers or year.

1. **Before assigning a new station ID, check the "current stations" table in the Water Quality Monitoring database to make sure a number hasn't already been assigned to that site**. Even if the site has not been collected before by the EFO, a station ID may have already been assigned based on other agency data (NPDES instream sampling, ARAP, special projects, TVA etc.). Do not assume that a station does not exist because it has not been collected by the EFO. It is very important that all data from a single location be given the same station ID to facilitate assessments based on all available information. Contact the Planning and Standards section if there is any question or if there are naming errors associated with existing stations.

   Unless the sites are located upstream and downstream of a point source discharge, tributary confluence or some other factor that would affect the stream, stations collected within 200 meters of each other are considered the same site**.** (So, if chemical samples were taken off the bridge and biological samples were collected up to 200 meters upstream, they are still the same station.)

   Chemical and biological stations collected more than 200 meters apart can still be considered the same station if there are no tributaries, discharges, construction, agriculture, road crossing or other activities that would influence the stream between sampling points. **It is very important for biological and chemical samplers to coordinate naming of station locations to avoid confusion.**

2. **The official stream name is the one found on the USGS 7.5 minute topographic map or equivalent GIS layer.** Do not use other sources such as gazetteer, TDOT bridge signs or local names, which may differ. (These may be included in the description line.)

3. **It is also important that river miles used in the station ID are measured as accurately as possible and correspond to the latitude and longitude for easy comparison between multiple stations on the same waterbody.** Only use GIS (preferred), map wheel or http://water.usgs.gov/osw/streamstats/tennessee.html to measure stream miles. Always use the 1:2400 scale. When using GIS use the ArcView measuring tool, do not use the NHD flowline layer or Reach File Index. Do not use TDEC on-line assessment map measuring tool as it is not accurate due to rounding.

   When measuring river miles for streams that enter an embayment, begin measurement from the confluence with the original channel of the main stem (not from where the stream becomes an embayment). For example, in Figure 1, river mile 0 for Bearden Creek would start at the confluence with the original channel of the Clinch River as marked on the topo within Melton Hill Lake. Follow the original stream channel line if marked on the topo (do not use "poly lines"). If the original stream channel is not marked on the topo, straight lines may be used through the embayment area.

   If there are other stations located on the same stream, make sure the assigned river miles are appropriately upstream or downstream of existing stations. If errors are discovered on existing stations, contact PAS to have the stations reassigned.

Figure 1: Start of river mile for measuring creeks within embayment areas.

The only exception to the naming scheme is sites that have been designated as Ecoregion or headwater reference sites. These sites are always identified with their ECO or FECO designation no matter what the purpose of sampling. If new ecoregion reference sites are added, contact Planning and Standards (PAS) to determine the appropriate station name.

4. Named streams/rivers

If a number does not already exist for the site, create an identification number. All letters in the station name are capitalized.

a. The first five digits will be the first five letters of the stream name (capitalized). If the stream name has more than one word, use the first letter of each word finishing out the five letters with the last word. For example, South Fork Forked Deer River would be SFFDE. Do not use the words River, Creek Branch etc. (Fork is only used if the stream is also designated river, creek, branch etc.) For example, Dry Fork would be DRY but Dry Fork Creek would be DFORK. **The stream name will be one designated on the 24 scale USGS topographical map or GIS layer. (Do not use the Gazetteer, local name, TDOT signs, etc.).**

b. The next five characters designate the river mile. This will be written as three whole numbers, a decimal and a tenth space. For example, river mile 1.2 would be written as 001.2. Do not add zeros to make a short stream name longer. It is very important that the river mile be determined as accurately as possible (see number 3 above).

c. The last two characters designate the county (or state if not in Tennessee). Use the County Identification table in Appendix B to determine the appropriate county designation. The county is expressed with two letters; do not use the numeric state code. If the station is in another state, add an underscore __ before the two letter state abbreviation.

Example 1: A station located at river mile 1.5 on Puncheoncamp Creek in Greene County would be PUNCH001.5GE

Example 2: A station located at river mile 25 on the North Fork Forked Deer River in Gibson County would be NFFDE025.0GI.

Example 3: A station that is located in Kentucky at river mile 15.2 of Spring Creek would be SPRIN015.2_KY.

5. Unnamed Streams/Tributaries.

Check a 24k scale topographic map (hardcopy or GIS) layer to see if the unnamed stream is within a named geographical features such as a cove, hollow, gulf, gulch or valley.

a. For streams that are not within a named geographical feature:

1) Use the first five letters of the receiving stream the tributary enters.

2) Use a 5-character stream mile to indicate where the tributary enters the main stem (whole number, decimal and tenth for example river mile 114.6 would be entered 114.6).

3) Use the letter T to indicate a tributary.

4) Use the river mile of the unnamed tributary where the station is located.

5) Use the two letter county abbreviation from Appendix B. If the station is in another state, add an underscore _ before the two letter state abbreviation.

Example 1: A station located at river mile 0.2 on an unnamed tributary that entered the Harpeth River at river mile 114.6 in Williamson County would be HARPE114.6T0.2WI.

Example 2: A second station at river mile 0.3 on the same trib would be HARPE114.6T0.3WI.

Example 3: A station located at river mile 5.5 on a different unnamed tributary which entered the Harpeth River at mile 115.0 in Williamson County would be HARPE115.0T5.5WI.

6) When naming an unnamed tributary to an unnamed tributary, start at the first named stream (mainstem) and work upstream to the sampling point.

a) Record the first five letters of the mainstem (named stream).
b) Record the river mile where the first unnamed tributary enters the main stem followed by a T.
c) Record the river mile where the second unnamed tributary enters the first one, followed by a T.
d) Record the river mile where the station is located, followed by the county designation.

Example: A station at river mile 0.5 on an unnamed tributary that flows into a second unnamed tributary at river mile 0.1 which, in turn flows into Turkey Creek at river mile 9.0 in Gibson County would be TURKE9.0T0.1T0.5GI (Figure 2).

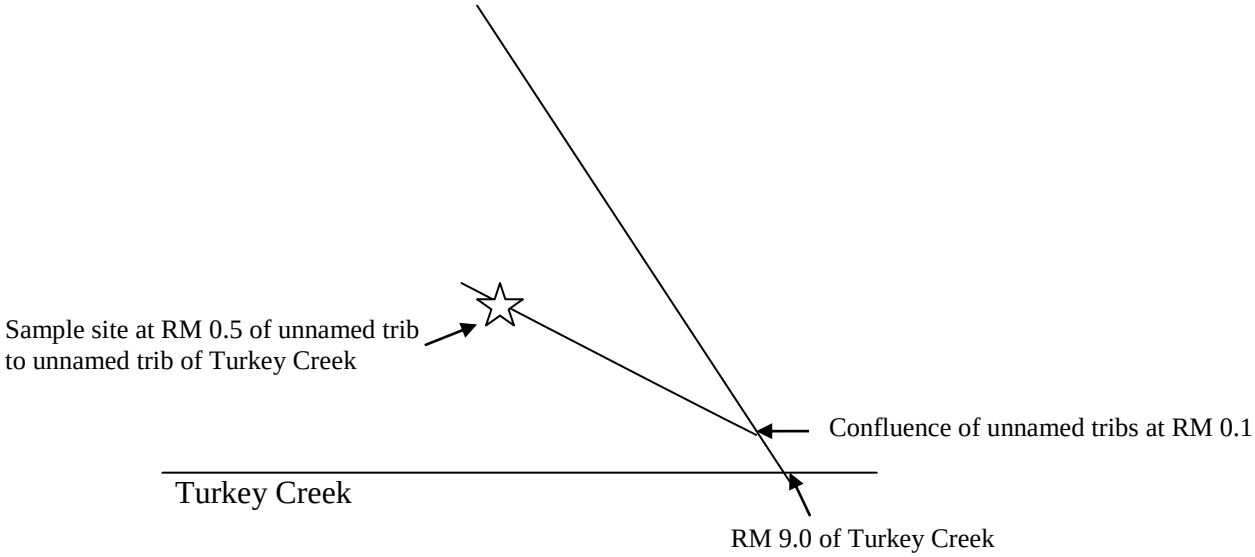

Figure 2: Illustration of naming scheme for stations located on unnamed tributaries to unnamed tributaries. Station ID TURKE9.0T0.1T0.5GI

b. For streams that are within a named geographical feature:

1) The first five digits will be the first five letters of the name of the geographical feature (capitalized). If the feature name has more than one word, use the first letter of each word finishing out the five letters with the last word. Do not use the words Cove, Hollow, Gulch, Gulf, or Valley. If the feature name has fewer than five letters use the entire name.

2) Add the underscore_G to indicate that the station is named after a geographical feature and not a named stream. Streams with "_G" will be the main branch running through the feature.

3) The next three characters designate the miles upstream from the nearest named stream or waterbody. This will be written as one whole number, a decimal and a tenth space. For example, river mile 1.2 would be written as 1.2. If the stream is an unnamed tributary to the main branch (_G streams), the miles will be measured upstream from the main branch instead of the nearest named stream or waterbody (see example 3).

4) Use the two letter county or state abbreviation from Appendix A. If the station is in another state, add an underscore _ before the two letter state abbreviation.

Example 1: A station that is in Shingle Mill Hollow in Marion County and is 0.3 miles upstream from Nickajack Reservoir, which is the closest named waterbody would be SMILL_G0.3MI.

Example 2: A station that is located on an unnamed main branch in Cave Cove in Marion County that is 0.4 miles upstream of the nearest named stream would be CAVE_G0.4MI.

Example 3: A station at river mile 0.2 on an unnamed tributary that enters main branch in Cave Cove at river mile 1.0 would be CAVE1.0G0.2MI.

6. Wetlands

a. For named wetlands

1) Use the first five letters of the wetland name if one word – if more than one word use the first letter of each word plus as many letters are needed in the last word to get five total letters (see 2.a).

2) Add underscore_W.

3) Use a 3-character stream mile including one whole number, the decimal and a tenth space. For example river mile 1.2 would be written as 1.2.

4) Use the two letter county or state abbreviation from Appendix A. If the station is in another state, add an underscore _ before the two letter state abbreviation.

Example 1: A station located at DUCK wetland would be DUCK_W1.2CH.

Example 2: A station located at BLACK HORSE wetland would be BHORS_W1.2CH.

b. For unnamed wetlands with an associated stream

1) Use the first five letters of the stream associated with the wetland if one word – if more than one word use the first letter of each word up to five letters (see 2. a.).

2) Add underscore_W

3) Use a 3-character stream mile including one whole number, the decimal and a tenth space. For example river mile 1.2 would be written as 1.2.

4) Use the two letter county or state abbreviation from Appendix A. If the station is in another state, add an underscore _ before the two letter state abbreviation.

Example: A wetland associated with a stream Clear Creek would be CLEAR_W1.2SM.

c. For isolated unnamed wetlands with no stream associated with it, use the name associated with the ARAP permit request.

1) Use the first five letters of the company associated with the wetland, - if more than one word use the first letter of each word up to five letters.

2) Add underscore_W.

3) Use a 3-character stream mile including one whole number, the decimal and a tenth space. For example river mile 1.2 would be written 1.2.

4) Use the two letter county or state abbreviation from Appendix A. If the station is in another state, add an underscore _ before the two letter state abbreviation.

Example: Company name Boones Farm BFARM_W1.2CO

7. Sinking streams (with no clear channel or surface flow to main stem – use standard naming scheme for streams with clear channel)

a. Use the first five letters of the stream name if one word – if more than one word use the first letter of each word up to five letters. For unnamed sinking streams or if the receiving stream is unclear use the first five letters of the closest mapped feature.

b. Add underscore _S.

c. Use a 3-character stream mile including one whole number, the decimal and a tenth space (use additional characters as needed if the stream mile is greater than 9.9). Start mileage from the point where the stream disappears (if the stream resurfaces downstream and it is clearly the same stream, estimate the distance between surface points).

d. Use the two letter county or state abbreviation from Appendix A. If the station is in another state, add an underscore _ before the two letter state abbreviation.

Example 1. A station located at river mile 1.2 on Dry Creek would be DRY_S1.2CU.

Example 2. A station located at river mile 11.2 on Stinky Cow Creek would be SCOW_S11.2CU.

Example 3. An unnamed sinking stream station located on Crane Top Ridge with no clear flow pattern would be CTOP_S1.2FR

8. Reservoirs (man-made lakes)

a. Assign the first 5 letters of the impounded stream (or embayment).

b. Use a 5 character stream mile if the sample is collected near the river channel. If the sample is collected near the right or left bank (such as at a boat dock) use a 4 character stream mile and the letter L or R to designate the right or left descending shore.

c. Use the appropriate 2 letter county or state abbreviation from Appendix A. Add an underscore _ before the two letter state abbreviation for stations in another state. For example, a station that was collected from a boat on Fishing Lake which dams Otter Creek in Anderson County would be OTTER012.3AN. If the station was collected off a dock near the left descending shore the station ID would be OTTER12.3LAN.

In the site description include the reservoir name as well as location for clarification (for example Otter Lake near boat dock)

9. Natural Lakes

a. Use the first 5 digits of the lake's name.

b. Using an S to designate station and a two digit whole number, assign the next available station ID. For example if station IDs 1 through 4 already exist on that lake from previous studies (check the water quality database) then use station ID 5. This would be designated S05.

c. Use the appropriate 2 letter county or state abbreviation from Appendix A. Add an underscore _ before the two letter state abbreviation for stations in another state.

For example, a new station located on Reelfoot Lake in Obion County would be REELFS11OB .

d. Assign the first 5 letters of the impounded stream (or embayment).

e. Use a 5 character stream mile if the sample is collected near the river channel. If the sample is collected near the right or left bank (such as at a boat dock) use a 4 character stream mile and the letter L or R to designate the right or left descending shore.

f. Use the appropriate 2 letter county or state abbreviation from Appendix A. Add an underscore _ before the two letter state abbreviation for stations in another state.

For example, a station that was collected from a boat on Fishing Lake which dams Otter Creek in Anderson County would be OTTER012.3AN. If the station was collected off a dock near the left descending shore the station ID would be OTTER12.3LAN.
In the site description include the reservoir name as well as location for clarification (for example Otter Lake near boat dock).

10. Duplicate Samples

A duplicate sample will be labeled with the appropriate station's ID and FD at the end.

Example: If a duplicate sample was taken at Puncheoncamp Creek at river mile 1.5, the label would read PUNCH001.5GE-FD.

Protocol C – General Collection Procedures

Sampler

Adapted from U.S. Environmental Protection Agency. 2002.

The primary objective of surface water sampling is to collect a representative sample that does not deteriorate or become contaminated before it is delivered to the laboratory. Generally, a sub-surface grab sample collected mid-channel is sufficient to document water quality for the space and time it was collected. Multiple or composite samples may more accurately represent water quality in large or slow flowing waterbodies.

For streams and rivers shallow enough to safely wade, samples should ideally be collected directly into the sample container from mid-channel or the middle of the thalweg if the main channel is not the middle of the stream (Protocol D). Samples should be collected 100 yards upstream from any bridges. If you are wading and it becomes too deep to safely wade to the thalweg, sampling outside the thalweg is acceptable as long as the location is in the channel and has sufficient flow. If a sample is taken outside the thalweg, comments that describe the location need to be recorded on the sample request form. Samples should never be collected from banks or docks unless the thalweg or the middle of the channel can be reached from this point. Do not sample if reduced to isolated pools. If drought conditions are suspected to affect stream data, flag with a D (similar to R flag for rain events). If a river, stream, or reservoir is too deep to wade or has dangerous current, mid-channel samples may be collected from a boat (Protocol E) or bridge (Protocol F). For large streams and rivers, combined grab samples collected at quarter-points (¼, ½ and ¾ width of channel) may result in more precise representation of water conditions.

Composite samples are a series of discrete, equal samples collected either at equal intervals of time (time composite) or relative to flow (flow proportional). Most commonly, composite samples are collected as part of NPDES compliance monitoring. Composite samples are usually collected with the use of an automatic sampler. See Protocol G for specific information on use of automatic samplers.

If possible, collect samples directly into the appropriate containers (Table 8). If the bottle contains a preservative, do not displace it while filling the container and leave adequate space in the sample bottle for mixing the preservative and the sample. To reduce the risk of bottle contamination, do not open the bottle until the sample is collected.

It is required that powder-free nitrile gloves be worn when collecting metal samples to avoid contamination of the sample. Either powder-free nitrile or latex gloves can be used for other sampling. Latex gloves may provide more protection from pathogens.

To avoid possible cross-contamination, it is recommended that tagged bottles be placed in unused colorless plastic zip-type bag. Store the sample on wet ice in a clean cooler until it is delivered to the lab. Each cooler must contain a temperature blank, used to measure cooler temperature upon arrival in the lab. Unless samples were collected within 2 hours of delivery to the lab, chemical samples warmer than 6°C are flagged, and bacteriological samples warmer than 10°C are flagged (Section II.B, # 4).

Table 8: Surface Water Sample Specifications

Sample Type	Bottle Type	Preservative	Holding Time
Bacteriological	Two 250 mL plastic (If sampling for just *E. coli*, only one bottle is needed)	Sodium thiosulfate ($Na_2S_2O_3$)	6 hours
Routine	1 liter or 1 gallon plastic depending on required analyses**	None	24 hours-28 days depending on required analyses**
Nutrient	500 mL plastic	1 mL sulfuric acid (H_2SO_4)*	48 hours -28 days depending on required analyses**
Metals	1 liter plastic	5 mL 70% nitric acid (HNO_3)*	6 months
Mercury[m]	1 liter plastic (same as above) or 500 mL plastic	5 mL (1-L) or 2.5 mL (500-mL) 70% nitric acid (HNO_3)*	28 days
Cyanide	1 liter plastic	pH>12; 5 mL of 50% sodium hydroxide (NaOH) at collection. If KI paper indicates chlorine, add 0.6g ascorbic acid ($C_6H_8O_6$) before adding NaOH. If sulfides are detected by lead acetate paper, add 1g of Cadmium Chloride ($CdCl_2$) after adding NaOH.	14 days
Oil & Grease	1 liter glass, wide mouth with Teflon® lid	2 mL sulfuric acid (H_2SO_4)*	28 days
Phenols, total	1 liter glass, amber	2 mL sulfuric acid (H_2SO_4)*	28 days
Sulfide	500 mL glass.	2 mL zinc acetate (ZnAc) in lab. 5 mL 50% sodium hydroxide (NaOH) in field	7 days
Boron	125 mL plastic	0.75 mL hydrochloric acid (HCl)*	6 months
Flash Point	16 ounce glass jar with Teflon® lid	None	None
TCLP	16-ounce glass jar	None	28 days
TOC	Three or four 40mL amber vials. (see page 12)	0.1mL phosphoric acid in each vial (H_3PO_4)	None specified
NPDES Extractables	1 gallon amber bottle, acetone-rinsed, and Teflon®-lined cap	None	7 days to extract; 40 days to analyze
Pesticides/PCBs			
TAL Extract.			
Nitrobodies			
Semivolatiles			

NPDES Volatiles TAL Volatiles	Five 40-mL amber vials, Teflon®-lined septa caps, no headspace	1:1 hydrochloric acid (HCl)*	14 days
BTEX GRO	Five 40-mL amber vials, Teflon®-lined septa caps, no headspace	1:1 hydrochloric acid (HCl)*	14 days
EPH	One 1-gallon amber bottle with Teflon® lined lid	1:1 hydrochloric acid (HCl)*	14 days

Store all samples on wet ice after collection.
*In very hot weather, store empty pre-preserved containers on ice to avoid vaporization.
**The specific parameters that can be analyzed from each sample are listed in Appendix B.
[m] 500 mL mercury bottles only need to be used for samples delivered to the Knoxville Lab or if mercury is the only metal that is being analyzed.

Sample Request Sheet and Chain of Custody Information

Following the sample collection, complete the sample tag (Protocol H) and the Sample Request Form (Protocol I). When collecting scheduled samples, much of this form may be completed before arrival at the sampling location. Pre-printed forms and labels may expedite scheduled sampling. In the header information, complete the primary sampler's name, collection date and time (military) after the sample is collected. Each sample will have a different time. Record the water parameters in the field determination box (Protocol J).

From the time of collection until analyses, custody of the sample must be traceable to assure integrity of the sample. A sample is considered to be in the custody of the primary sampler if it is in the sampler's possession or secured in a tamper-proof way in a restricted area. Make sure the doors are locked, if the sample is left unattended in a vehicle.

The primary sampler signs the "Collected by" line under chain of custody and fills in the date and military time of collection (Section II.D). The entire chain of custody must be completed (Protocol I). If the sample is given to anyone else (TDEC staff, courier, etc.) for transport to the laboratory, then they are responsible for the integrity of the sample and must sign the chain of custody on the Sample Request Form when taking custody of the sample.

Custody Seal

A custody seal assures the sample integrity has not been compromised. It is recommended that once samples have been placed on ice in the cooler, a signed and dated custody seal be attached to the cooler in such a way that it must be broken to open the cooler. A signed and dated custody seal (Figure 3) is only required if the sample is transferred from the primary sampler's custody (i.e. other TDEC staff, bus, courier, etc.) before reaching the laboratory. Any signed and dated custody seal may be used.

"The use of custody seals may be waived if field investigators keep the samples in their custody as defined from the time of collection until the samples are delivered to the laboratory analyzing the samples." (*Ecological Assessment Standard Operating Procedures and Quality Assurance Manual.* USEPA Region 4, 2002).

1. It is in the actual possession of an investigator;
2. It is in the view of an investigator, after being in their physical possession;
3. It was in the physical possession of an investigator and then it was secured to prevent loss or tampering; and/or;
4. It is placed in a designated secure area.

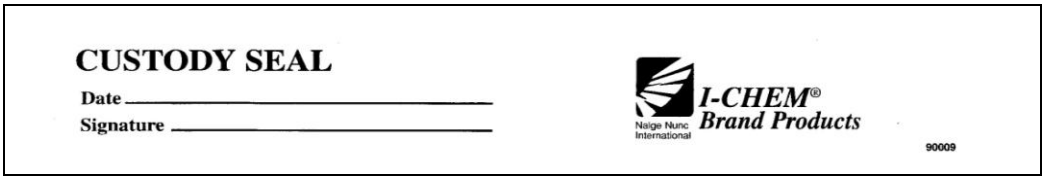

Figure 3: Custody Seal Example.

Delivery to the State Laboratory

Samples are to be delivered to the state laboratory, Tennessee Department of Health, in Nashville, Knoxville, Jackson, or Memphis. Contact the laboratory if samples cannot be delivered during normal hours of operation 7:00 – 4:30 (2:30 for bacteriological samples) Monday through Friday (Monday – Thursday for bacteriological samples). If samples cannot be delivered during normal hours of operation and holding times are not an issue, secure the samples in a locked area in the EFO and deliver them to the laboratory the next day. The samples must be stored at ≤ 6ºC. If holding times are an issue, and the sample cannot be delivered during normal working hours, contact the laboratory by 12:00 pm to inform the lab of late delivery.

Nashville Central Laboratory
630 Hart Lane
Nashville, Tennessee 37247
Environmental Sample Coordinator: 615-262-6342
Microbiological Sample Coordinator: 615-262-6371

Knoxville Regional Laboratory
1522 Cherokee Trail
Knoxville, Tennessee 37290
865-549-5279

Jackson Regional Laboratory
295 Summar Drive
Jackson, Tennessee 38301
731-426-0685

After hours emergency (all labs): 615-262-6300

Field Equipment Cleaning

All reusable equipment that comes in direct contact with sample water must be cleaned between uses. If it is not possible to return to the EFO lab to clean sampling equipment between uses, the equipment may be field-cleaned. Replace any contaminated tubing between sites. All contaminated wastes or suspected contaminated wastes must be contained in a bucket with a snap or screw-on lid. Document any deviation from this procedure.

1. **Soap Wash** – Wash the equipment with phosphate-free laboratory detergent such as Alconox® or Sparkleen® and tap water. The soapy water can be dispensed from a squeeze bottle. Use a clean scrub pad to remove any surface film or particulate matter. The wash water can be disposed in the sanitary drain in the washroom, or while in the field, washed onto pervious ground without recovery.

2. **Tap Water Rinse** – Rinse the equipment thoroughly with tap water from a squeeze bottle or other appropriate bottle. Store tap water in any clean and covered tank or bottle. The rinse water can be disposed in the sanitary drain in the washroom, or while in the field, washed onto pervious ground without recovery.

3. **Deionized Water Rinse** – Rinse equipment thoroughly with deionized water using a squeeze bottle. Store deionized water in a labeled, clean covered glass or plastic tank or bottle. If the sampling equipment is being cleaned for the collection of organic samples, rinse with organic-free reagent-grade water dispensed from Teflon® squeeze bottle. The rinse water can be disposed in the sanitary drain in the washroom, or while in the field, washed onto pervious ground without recovery.

4. **Storage –** Store equipment in a clean area until used.

5. **Sample Water Rinse -** At the site before collecting the sample, rinse the sampling equipment at least once in the creek, river, or reservoir water.

Sample Types

The specific type of chemical or bacteriological sample that needs to be collected will vary with the sampling objectives and funding priorities. The most common sample types are discussed below. If additional samples are collected, contact the receiving laboratory for collection instructions.

1. Bacteriological Sample Collection

When collecting *E. coli* samples to calculate a geometric mean for comparison to water quality criteria, five samples must be collected within a 30 day period with samples being at least 24 hours apart. Ideally samples should be collected between March and November. Rain events should be avoided. Additional samples must be collected, with dilutions requested if any samples are reported as "less than" or "greater than" to achieve 5 measurable samples in 30 days.

Powder free gloves should be worn to avoid contamination of bacteriological samples. It is recommended that shoulder length gloves be worn in waters known or suspected to have high pathogen levels to protect the sampler from possible health risks. Do not use any equipment that has not been sterilized to collect bacteriological samples. If requesting multiple analyses, collect <u>two</u> 250-milliliters sterilized pre-preserved bottles to ensure an adequate sample volume is available for analyses. If only collecting *E. Coli* one bottle will suffice. Do not open the sterilized bottle until the sample is collected. When handling the sample container take care not to contaminate the lid or the inside of the bottle. When the sample is collected, leave ample air space in the bottle (about an inch) to facilitate mixing by shaking. Do not overfill the bottle and displace the preservative. After filling the bottle, carefully replace the lid and shake the bottle to assure adequate mixing of the sodium thiosulfate.

After the lids have been placed on the bottles, attach a completed sample tag to each bottle. Fill in Site No. (sample ID), two-digit Tennessee County Code, Date, Military Time, Station Location and Samplers on the sample tag. The primary sampler's name must be on the sample tag. The two bottles are considered one sample, so write the same collection time on both tags. Check "yes" under preservative and place an "X" beside Microbiological.

If chemical analyses are also requested, the microbiologists may not receive their copy of the Sample Request Form before the sample is analyzed; therefore write the needed analyses (i.e. *E. coli*, fecal coliform, and/or fecal strep.) and if dilution is requested in the remarks box on the sample tag. For *E. coli* analysis, if historical readings have been higher than 1000, request in the remarks box that sample be diluted 1:100. If historical *E. coli* readings have been less than 1000, no specific notations are needed. Refer to Protocol A for additional guidelines for determining if diluted sample analysis should be requested.

To avoid cross-contamination, it is recommended that tagged bottles be placed in a colorless zip-type plastic bag and then stored on ice in a sealed cooler until delivered to the lab. Make sure each cooler contains a temperature blank, which is used to measure cooler temperature upon arrival in the lab. Bacteriological samples should be no warmer than 10^{o}C, unless they are collected within two hours of delivery to the laboratory. Bacteriological samples must be delivered to TDH Microbiology Laboratory or any other TDEC contract laboratory within 6 hours of the collection time. If samples cannot be delivered by 2:30 PM, the laboratory must be notified by noon. If another TDEC contract laboratory is used, check with them on the days and times samples are accepted.

2. Inorganic Sample Collections

a. Routine Sample Collection

Routine samples require no preservative and are collected in certified pre-cleaned single-use gallon or liter plastic bottles. See Appendix B for the volume of sample required for various routine analyses. If multiple analyses are requested, collect a gallon of sample water. Contact the receiving laboratory if there is a question about the volume of sample to collect for proper analyses and QC.

After the sample container is filled, complete the sample tag by writing Site No. (sample ID), two-digit Tennessee County Code, Date, Military Time, Station Location and Samplers. The primary sampler's name must be on the sample tag. Check the "no" box under Preservative. Write Routine in one of the empty lines under Analyses. Attach the completed Routine tag to the filled sample bottle, place it in a zip-type plastic bag (optional) and store on ice until delivery to the laboratory.

b. Nutrient Sample Collection

Nutrient samples are collected in certified pre-cleaned single-use 500-milliliters plastic bottles preserved with 1-milliliter sulfuric acid. In hot weather, store acid pre-preserved bottles on ice until needed to avoid vaporization and a potentially hazardous situation. Use only phosphate-free soap for hand washing or sampling equipment cleaning prior to obtaining nutrient samples. Always wear powder-free gloves when collecting nutrient samples. Fill the sample bottle with sample water, but do not overfill the bottle and displace the preservative. Note that nitrite and orthophosphate samples are analyzed from the routine sample bottle and are not preserved.

Complete the sample tag by filling in Site No. (sample ID), two-digit Tennessee County Code, Date, Military Time, Station Location and Samplers. The primary sampler's name must be on the sample tag. Check the "yes" box under preservative. Under Analyses check the COD, TOC, Nutrient line and circle Nutrient. Attach the completed Nutrient tag to the filled sample bottle and place it in a zip-type bag (optional). Store the sample on ice until delivery to the laboratory.

c. Routine Metals and Mercury Sample Collection

Routine metal samples are collected in certified pre-cleaned single-use 1-liter plastic bottles preserved with 5-mL nitric acid. If mercury samples are sent to the Knoxville or Jackson Labs, or if mercury is the only metal being analyzed, then collect in pre-cleaned, single-use 500-mL plastic bottles preserved with 2.5-mL nitric acid. Otherwise, the mercury can be collected in the same 1-liter plastic bottle as the routine metals. In hot weather, store acid pre-preserved bottles on ice until needed to avoid vaporization and a potentially hazardous situation.

Most metal samples may be collected using the same collection techniques used to collect other chemical samples. Wear powder-free nitrile gloves when sampling. If sampling for dissolved metals, the sample water will need to be filtered through a 0.45µ pore diameter membrane filter in the field prior to preservation. EPA has recommended that any intermediate sampling devices used to collect mercury samples be constructed of Teflon®. If trace metals or low-level mercury are a concern, collect samples using the modified clean technique specified in 2-d.

Fill the sample bottle with sample water, but do not overfill the bottle and displace the preservative. Complete the sample tag by filling in Site No. (sample ID), two-digit Tennessee County Code, Date, Military Time, Station Location and Samplers. The primary sampler's name must be on the sample tag. Check the "yes" box under preservative. Under Analyses, check the "Metals" line. Attach the completed Metals tag to the filled sample bottle, and place it in a zip-type bag (optional). Store the sample on ice until delivery to the laboratory.

d. Trace Metals and Low-Level Mercury Sample Collection
Modified Clean Technique

This sampling method is adapted from U.S. Environmental Protection Agency. 1996. *Method 1669, Sampling Ambient Water for Trace Metals at EPA Water Quality Criteria Levels.* Office of Water Engineering and Analysis Division (4303). Washington, DC.

The modified clean technique is used for trace metal and low-level mercury collections. This method is not intended for collection of metals or mercury to be analyzed at minimum detection levels (MDL) available at most environmental laboratories including the TDH Environmental Laboratories. Only ultra-clean laboratories are able to obtain MDL necessary to analyze samples for trace metals.

It cannot be overemphasized how easily samples can be contaminated with trace metals. The detection levels for most metals are parts-per-billion (ug/l) or parts-per-trillion range. The modified clean sampling method is designed to reduce the probability of contamination when collecting a sample to be analyzed for trace metals.

Many lotions, sunscreens, and insecticides contain trace amounts of metals and should not be worn when collecting trace metal samples. Atmospheric metals from automobile exhaust, cigarette smoke, bridges, wires or poles can also contaminate the sample. To avoid possible contamination, collect trace metal and low-level mercury samples at least 100 yards upstream of bridges, wires, poles, or roads.

Wear powder-free nitrile gloves when handling sample containers. Other gloves contain high levels of zinc and are likely to contaminate the sample, and must not be used. If more than one sample is collected on the same waterbody, collect in the area believed to have the lowest metal contamination level first and the area with the highest metal concentration last.

A 1-liter pre-cleaned, single-use plastic bottle preserved with 5-mL nitric acid provides sufficient sample volume for all metals. If mercury samples are sent to the Knoxville Lab or if mercury is the only metal being analyzed, then collect in pre-cleaned, single-use 500-mL plastic bottles preserved with 2.5-mL nitric acid. Otherwise, the mercury can be collected in the same 1-liter plastic bottle as the other metals.

Designate one sampler as “clean hands” and the other as “dirty hands”. The “clean hands” designee conducts any activities involving the sample container and inner storage bag. The “dirty hands” designee is responsible for all other activities. The “clean hands” designee wears shoulder length powder-free gloves during the sampling event. The “dirty hands” designee may wear short powder-free gloves.

The “dirty hands” designee removes the sample containers from the cooler and opens the outer bag. The “clean hands” designee opens the inner bag, removes the sample container and moves to the appropriate sampling area. Then the “clean hands” designee removes the container lid and fills the sample container(s) upstream of all water movement, being careful not to displace the preservative. After the sample bottle is filled, the “clean hands” designee replaces the lid tightly, shakes the bottle to mix the preservative and returns it to the sample staging area.

The “dirty hands” designee is considered the primary sampler and completes the sample tag by filling in Site No. (sample ID), two-digit Tennessee County Code, Date, Military Time, Station Location and Samplers. Check the “yes” box under preservative. Under Analyses, check box beside Metals. For mercury samples, write “Mercury” in one of the blank lines under Analyses. Attach the tag to the sample. “Clean hands” designee then places the sample in the inner zip bag and seals it. The “Dirty Hands” designee seals the outer zip bag and places the sample on wet ice in a clean non-metallic cooler with a temperature blank.

Trace metal and low-level mercury samples cannot be collected from a bridge or pier due to likely contamination from the structure. In non-wadeable rivers or reservoirs, if possible collect metal and mercury samples from a boat constructed of a non-metal

material like plastic or fiberglass. When feasible, paddling or electric motors are preferable to gasoline motors, since gasoline is a potential source of contamination. If the waterbody is too large to gain access to the sampling location without the use of a gasoline motor, turn off the motor a sufficient distance from the sampling location to avoid contamination and paddle the remainder of the way to the sample location.

Always approach the sampling location from downstream. The "clean hands" designee may collect subsurface grab samples from the bow of the boat. If the study objective requires a mid-depth sample in non-wadeable waterbodies, collect the sample with the use of a properly cleaned (Section I.H) discrete depth sampler (Kemmerer) constructed of Teflon® with no metal parts. Only the "clean hands" designee is to handle the Kemmerer, sample bottles and the inner zip bag. The "dirty hands" designee controls the boat location and handles all non-sample contact duties.

e. Cyanide Sample Collection

Cyanide analysis requires a 1-liter sample collected in a certified pre-cleaned single-use plastic bottle. Test the sample for the presence of chlorine by placing a drop of sample on Potassium Iodine (KI) paper moistened with acetate buffer. If the KI paper turns blue indicating the presence of chlorine, neutralize the chlorine with 0.6 grams of ascorbic acid. If sulfides are suspected, test for the presence of sulfides by placing a drop of sample on acidified lead acetate test paper (gray indicates sulfides are present). Field preserve cyanide samples to a pH greater than 12 by adding 5-milliliters of 50 percent sodium hydroxide to the sample. If sulfides were present, add 1g of Cadmium Chloride ($CdCl_2$) for each liter of sample after the pH has been raised.

Complete the sample tag by filling in Site No. (sample ID), two-digit Tennessee County Code, Date, Military Time, Station Location and Samplers. The primary sampler's name must be on the sample tag. Check the "yes" box under preservative. Place an "X" in the box beside Cyanide. Tighten the lid on the sample bottle and attach the completed tag to the sample bottle, place in a zip-type bag (optional) and store on ice until delivery to the lab.

f. Oil and Grease Sample Collection

Oil and Grease analyses require at least 1-liter sample collected in a wide mouth glass jar with a Teflon® lined lid and preserved with 2-milliliters sulfuric acid. Consult the receiving laboratory to determine if more than 1-liter sample is needed to achieve a homogeneous sample. Do not displace the preservative while filling the jar. Attach a completed sample tag with Site No. (sample ID), two-digit Tennessee County Code, Date, Military Time, Station Location and Samplers. The primary sampler's name must be on the sample tag. Check the "yes" box under preservative. Write "Oil and Grease" on the empty line under Analyses. Place the sample in a zip-type bag (optional) and store on ice until delivery to the laboratory.

g. Phenols Sample Collection

Phenol analysis requires 1 liter of sample collected in an amber glass jar preserved with 2-milliliters of sulfuric acid. Do not displace the preservative while filling the jar. Attach a completed sample tag with Site No. (sample ID), two-digit Tennessee County Code, Date, Military Time, Station Location and Samplers. The primary sampler's name must be on the sample tag. Check the "yes" box under preservative. Write "Phenols" on an empty line under analyses. Place the sample in a zip-type bag (optional) and store on ice until delivery to the laboratory.

h. Sulfide Sample Collection

Sulfide analysis requires 500-milliliters of sample collected in a glass jar. Sulfide samples are preserved in the laboratory with 2-milliliters of zinc acetate and in the field with 5-milliliters of 50 percent sodium hydroxide. Do not displace the preservative while filling the jar. Attach a completed sample tag with Site No. (sample ID), two-digit Tennessee County Code, Date, Military Time, Station Location and Samplers. The primary sampler's name must be on the sample tag. Check the "yes" box under preservative. Write "Sulfide" on an empty line under analyses. Place the sample in a zip-type bag (optional) and store on ice until delivery to the lab.

i. Boron Sample Collection

Boron analysis requires 125-milliliters of sample collected in a certified pre-cleaned, single-use plastic bottle preserved with 0.75-milliliter of hydrochloric acid. Do not displace the preservative while filling the bottle. Attach a completed sample tag with Site No. (sample ID), two-digit Tennessee County Code, Date, Military Time, Station Location and Samplers. The primary sampler's name must be on the sample tag. Check the "yes" box under preservative. Write "Boron" on an empty line under analyses. Place the sample in a zip-type bag (optional) and store on ice until delivery to the lab.

j. Flash Point Sample Collection

Flash point is a regulatory test to determine if a substance is flammable at temperature below 60^{o}C. Therefore, do not subject any suspected substance to heat or possible ignition source. Flash point analysis requires collection in a 16-ounce glass jar with a Teflon® lined lid. No preservative is needed.

Fill the jar with sample water and attach a completed sample tag with Site No. (sample ID), two-digit Tennessee County Code, Date, Military Time, Station Location and Samplers. The primary sampler's name must be on the sample tag. Check the "no" box under preservative. Write "Flash Point" on an empty line under analyses. Place the sample in a zip-type bag (optional) and store on ice until delivery to the laboratory.

k. TCLP Sample Collection

Toxicity Characteristic Leaching Procedure (TCLP) test is used to simulate the mobility of analytes from wastes. This is most commonly a regulatory test performed on wastes and soils collected from landfills (Solid Waste) or superfund sites. This test has specific requirements. If the sample contains less than 0.5 percent solids, the liquid is classified as TCLP extract. If the sample contains more than 0.5 percent solids, enough sample must be filtered to get at least 100 grams of solids to perform the extraction. It could take copious amounts of sample to obtain 100 grams of solids.

Collect TCLP samples in a clean 16-ounce glass jar with no preservative. A great deal more sample may be required if more than 0.5 percent solids are found in the initial analysis. Complete the sample tag by filling in Site No. (sample ID), two-digit Tennessee County Code, Date, Military Time, Station Location and Samplers. The primary sampler's name must be on the sample tag. Check the "no" box under preservative. Write "TCLP" in one of the empty lines under analysis. Attach the completed TCLP tag to the sample bottle, place it in a zip-type bag (optional) and store on ice until delivery to the laboratory.

l. Total Organic Carbon Sample Collection

TOC samples are collected in three 40-milliliter amber vials preserved with 0.1mL of phosphoric acid per vial. One site for each sampling run needs to have four vials collected for QC purposes. If a sample run has more than 10 sites where TOC samples are collected, then four vials will be needed at two of the sites. Only fill the vials to the neck leaving a head space in the vial. Do not displace the preservative while filling the vials. Disposable beakers that can be purchased from Laboratory Inventory can be used to fill TOC vials (optional). These beakers must be disposed of after use at one site. They cannot be re-used at another site, but must be discarded. Use a new beaker at every site TOC is collected. Complete the sample tag by filling in Site No. (sample ID), two-digit Tennessee County Code, Date, Military Time, Station Location and Samplers. The primary sampler's name must be on the sample tag. Check the "yes" box under preservative. Write "TOC" in one of the empty lines under Analyses. Attach one completed TOC tag to the sample vials and place them in one zip-type bag, and store on ice until delivery to the laboratory. In hot weather, store acid pre-preserved vials on ice until needed to avoid vaporization and a potentially hazardous situation.

3. Organic Sample Collections

a. Base/Neutral/Acid Extractable Compounds

(1). NPDES Extractable Sample Collection

NPDES Extractable analyses require a one-gallon sample collected in an acetone-rinsed amber glass bottle with a Teflon® lined lid. No preservative is needed. Fill the bottle with sample water and complete a sample tag with Site No. (sample ID), two-digit Tennessee County Code, Date, Military Time, Station Location and Samplers. The primary sampler's name must be on the sample tag. Check the "no" box under preservative. Place an "X" beside Extractable Organics and write "NPDES" on one of the blank lines under analyses. Attach the tag to the bottle and place the sample in a zip-type bag (optional) and store on ice until delivery to the laboratory.

(2). Pesticides/PCBs Sample Collection

Pesticide and PCBs analyses requires one-gallon sample collected in an acetone-rinsed amber glass bottle with a Teflon® lined lid. No preservative is needed. Fill the bottle with sample water and complete a sample tag with Site No. (sample ID), two-digit Tennessee County Code, Date, Military Time, Station Location and Samplers. The primary sampler's name must be on the sample tag. Check the "no" box under preservative. Place an "X" beside pesticides/PCBs under Analyses. Attach the sample tag to the bottle and place the sample in a zip-type bag (optional) and store on ice until delivery to the laboratory.

(3). Target Analyte List Sample Collection

Target Analyte List (TAL) analyses require a one-gallon sample collected in an acetone-rinsed amber glass bottle with a Teflon® lined lid. No preservative is needed. Fill the bottle with sample water and complete a sample tag with Site No. (sample ID), two-digit Tennessee County Code, Date, Military Time, Station Location and Samplers. The primary sampler's name must be on the sample tag. Check the "no" box under preservative. Write "TAL" in one of the blank lines under Analyses and place an "X" in the box to the right. Attach the sample tag to the bottle and place the sample in a zip-type bag (optional) and store on ice until delivery to the laboratory.

(4). Nitrobodies Sample Collection

Nitrobodies tests are run to analyze for six explosive compounds, so handle these samples very carefully and protect the sample from heat sources. Nitrobodies analyses requires one-gallon sample collected in an acetone-rinsed amber glass bottle with a Teflon® lined lid. No preservative is needed.

Fill the bottle with sample water and complete a sample tag with Site No. (sample ID), two-digit Tennessee County Code, Date, Military Time, Station Location and Samplers. The primary sampler's name must be on the sample tag. Check the "no" box under preservative. Write "Nitrobodies" in one of the blank lines under Analyses and place an "X" in the box to the right. Attach the sample tag to the bottle and place the sample in a zip-type bag (optional) and store on ice until delivery to the laboratory.

(5). Semivolatiles Sample Collection

Semivolatiles analyses require a one-gallon sample collected in an acetone-rinsed amber glass bottle with a Teflon® lined lid. No preservative is needed. Fill the bottle with sample water and complete a sample tag with Site No. (sample ID), two-digit Tennessee County Code, Date, Military Time, Station Location and Samplers. The primary sampler's name must be on the sample tag. Check the "no" box under preservative. Write "Semivolatiles" in one of the blank lines under Analyses and place an "X" in the box to the right. Attach the sample tag to the bottle and place the sample in a zip-type bag (optional) and store on ice until delivery to the laboratory.

b. Volatile and Petroleum Hydrocarbon Compounds

Since volatile organic compounds may be present in concentrations of micrograms per liter, they may be lost when improperly handled. Avoid sampling in turbulent areas. Collect volatile organic samples directly into the appropriate pre-preserved amber vial or bottle (Table 8). All lids used for volatile organic samples must be Teflon® lined. Pour the sample slowly down the side of the container to avoid turbulence that could produce volatilization.

Slightly overfill bottles and vials to produce a convex meniscus without losing the preservative. The lid may be used to capture a small amount of sample to help produce the convex meniscus. A small amount of overflow should occur when the lid is tightened down. After placing the lid tightly on the bottle or vial, invert it and tap on the container while watching for air bubbles. If any bubbles are present, repeat the process with another clean preserved bottle or vial.

(1). NPDES and TAL Volatile Sample Collection

To collect a NPDES or TAL volatile sample, fill five 40-milliliters amber pre-preserved vials with Teflon® lined septa caps. Each vial is pre-preserved with 1:1 hydrochloric acid. To keep the sample together, place a rubber band around the five vials. Fill out one tag and attach it to all five vials. Complete the sample tag with Site No. (sample ID), two-digit Tennessee County Code, Date, Military Time, Station Location and Samplers. The primary sampler's name must be on the sample tag. Check the "yes" box under preservative. Mark the box beside Volatile Organics under Analyses and write the specific requested analyses in one of the empty lines. Place all five rubber banded vials in a zip-type colorless plastic bag and store on ice in a clean cooler until delivery to the laboratory for analyses.

(2). BTEX and GRO Volatile Sample Collection

To collect a BTEX or GRO volatile sample, fill five 40-milliliters amber pre-preserved vials with Teflon® lined septa caps. Each vial is pre-preserved with 1:1 hydrochloric acid. To keep the samples together place a rubber band around the five vials. Fill out one tag and attach it to all five vials.

Complete the sample tag with Site No. (sample ID), two-digit Tennessee County Code, Date, Military Time, Station Location and Samplers. The primary sampler's name must be on the sample tag. Check the "yes" box under preservative. Place an "X" in the box beside Volatile Organics under Analyses and write the specific requested analyses in one of the empty lines. Place all five rubber banded vials in a zip-type colorless plastic bag and store on ice in a clean cooler until delivery to the laboratory for analysis.

(3). EPH Volatile Sample Collection

To collect EPH volatile sample, fill one 1-gallon pre-preserved amber bottle with a Teflon® lined lid. The bottle is pre-preserved with 1:1 hydrochloric acid. Complete the sample tag with Site No. (sample ID), two-digit Tennessee County Code, Date, Military Time, Station Location and Samplers. The primary sampler's name must be on the sample tag. Check the "yes" box under preservative. Place an "X" in the box beside Volatile Organics under Analyses and write EPH in one of the empty lines. Attach the sample tag to the bottle and place the sample in a zip-type bag (optional_ and store the sample on ice in a clean cooler until delivery to the laboratory for analysis.

Protocol D – Surface Water Collections in Wadeable Rivers and Streams

Sampler

Adapted from U.S. Environmental Protection Agency. 2002. *Ecological Assessment Standard Operating Procedures and Quality Assurance Manual.* Region 4. Atlanta, GA.

In streams and rivers shallow enough to wade (generally less than 4 feet, unless there is a strong current)**,** submerge the sample container directly in the water column (grab sample) to collect the sample. When a stream is very shallow, the sample container does not have to be completely submerged. Use a disposable beaker to fill the bottle. If multiple sample containers are going to be filled at the same station, fill the unpreserved sample (routine) first, then the bacteriological, nutrients, and the metal samples last. Collect subsequent samples upstream of the previous sample to avoid possible contamination from the substrate or previous preservatives.

To collect a surface water sample using the sample container, wade to the thalweg, face upstream and collect the sample without disturbing the sediment. If sediment disturbance is unavoidable collect the sample upstream of the sediment plume or wait until the disturbed sediment moves downstream. If it becomes too deep to wade to the thalweg, sampling outside the thalweg is acceptable as long as the location is in the channel and has sufficient flow. Never collect samples from bank, dock, pier etc. unless thalweg can be reached from this point. If a sample is taken outside the thalweg, comments that describe the location need to be recorded on the sample request form. Remove the lid without contaminating the lid or the inside of the sample container. Grasp the bottle near the base and dip it midway in the water column. Collect samples in one arching motion to avoid losing the preservative. If the sample bottle contains a preservative, do not overfill it and displace the preservative. Tightly replace the lid and shake preserved bottles to assure adequate mixing of the preservative.

After collecting the sample, wade back to the sample staging area and attach a completed sample tag to the bottle. Place the sample inside a zip-type bag (optional) and store on ice until delivery to the laboratory. See Protocol C for general collection techniques and additional precautions when collecting trace metal or low-level mercury samples. Protocols H and I describe the procedure for completing sample tags and Sample Request Forms.

Protocol E – Surface Water Collections from a Boat

Sampler

Adapted from U.S. Environmental Protection Agency. 2002.

In streams, rivers, reservoirs, or lakes too deep for wading the best means of obtaining water samples is from a boat either directly into the sample container or with the use of a discrete depth sampler. Make all collections from the bow of the boat while the boat is facing upstream. Collect the samples upstream of the boat's movement. If multiple sample containers are going to be filled at the same station, fill the unpreserved sample (routine) first, then the bacteriological, nutrients, and the metal samples last. Collect subsequent samples upstream of the previous samples to avoid possible contamination from prior preservatives.

Collect subsurface grab water samples from the bow of the boat while the boat is facing upstream. Remove the lid without contaminating the lid or the inside of the sample container. Grasp the bottle near the base and dip it in the water column with a forward upstream motion. If the sample bottle contains a preservative, do not overfill it and displace the preservative. Tightly replace the lid and shake preserved bottles to assure adequate mixing of the preservative.

To collect mid-depth samples, use a discrete depth sampler, such as a Kemmerer. Any equivalent discrete depth sampler may be used as long as it samples from the desired depth, is constructed of a material that will not contaminate the sample, such as Teflon®, and is easily cleanable. Reusable discrete depth samplers cannot be sterilized; therefore, bacteriological samples cannot be collected with this equipment.

The location and number of samples will vary depending on the purpose of the sample. In reservoirs and lakes with little flow, multiple samples may be required to accurately represent water conditions. Composite samples collected at quarter-points (¼, ½, ¾) may more accurately represent water conditions for large bodies of water.

A Kemmerer is a cylinder, with Teflon® or silicone stoppers on each end, attached to a rope. The rubber stoppers can be closed remotely with a weighted messenger. Lock the stoppers in the open position to allow water to flow through the device as it is lowered to the correct depth.

When the Kemmerer reaches the proper depth (usually mid-depth), slide the messenger down the rope to close the stoppers and capture a water sample. Raise the Kemmerer out of the water by the rope. Open the valve on the Kemmerer to fill the appropriate sample bottles. Repeat this process as many times as necessary to collect a sufficient volume of water to fill all sample bottles.

Collect an equipment blank (Section II.B), before the sample is collected, on the clean discrete sampling device at every tenth site the equipment is used to assure the sample is not being contaminated by collection equipment. Before reusable equipment such as a Kemmerer can be

used, it must be properly cleaned to avoid the possibility of cross-contamination. See Section I.H for laboratory cleaning procedures. If it is not possible to return to the EFO lab between uses, discrete or intermediate sampling devices may be field cleaned between sites using field cleaning procedures in Protocol C.

Measure water quality parameters (DO, pH, temperature, and conductivity) at each sample site. Rinse the probes with surface water prior to measurement. If the cord on the water parameter probe is long enough to reach mid-depth in waters 10 feet deep or less, lower the probe to the mid-depth and allow it to equilibrate. For sampling in waters deeper than 10 feet, measure the water parameters at a depth of 5 feet, unless a different depth is specified in the criteria or by the study objectives. Some studies may require additional readings to measure water quality profiles.

Protocol F – Surface Water Collections from a Bridge

Sampler

Adapted from U.S. Environmental Protection Agency. 2002.

The primary concerns when sampling from a bridge is the safety of personnel and the integrity of the water sample. For the safety of staff as well as motorists, follow OSHA precautions from *Manual on Uniform Traffic Control Devices* (1993) outlined in Procedure I.D. If the stream is wadeable, it is recommended that samples not be collected from the bridge. Generally, the sample should be collected in the thalweg. The location, depth, and number of samples will vary depending on the purpose of the study.

Collect the samples from the upstream side of the bridge. Handle the sampler carefully to avoid dislodging dirt and other contaminants from the bridge into the sample container or sampling device.

1. Subsurface sample collection

Subsurface samples may be collected from a bridge directly into the appropriate sample container with the use of a bottle holder connected to a long handle, a rope and bottle holder, or an intermediate sampling device. If an intermediate device is used, collect an equipment blank (Section II.B) at every tenth sample after the equipment is cleaned and before samples are collected to assure they are not being contaminated by the collection method.

Due to likely contamination, chemical samples may not be collected from a PVC plastic bucket or bailer. A properly cleaned (Protocol C) Teflon® or High Density Polyethylene (Nalgene®) bucket or bailer may be used to collect metals (other than trace level metal or mercury), nutrient, and routine samples. EPA recommends use of a Teflon® bucket or bailer to collect mercury samples. Samples for trace metal analyses must be collected using the modified clean technique (Protocol C).

Subsurface organic samples may be collected with the use of a properly cleaned stainless steel bucket or bailer. Bacteria samples must be collected using a sterile container. Subsurface bacteria samples may be collected from a bridge, pier, or bank directly into a sterile sampling container using a bottle holder connected to a long handle, a rope and bottle holder, or into a sterile intermediate sample container. Sterile disposable containers or intermediate samplers that can be sterilized without being damaged by autoclaving may also be used to collect bacteriological samples. If multiple sample containers are going to be filled at the same station, fill the unpreserved sample (routine) first, then the bacteriological, nutrients, and the metal samples last.

2. Mid-depth sample collection

If the study objective requires mid-depth chemical sample collection, a discrete depth sampler may be used to collect mid-depth samples. See Protocol C for specifications, use, and field cleaning procedures of discrete depth samplers. Protocol I.H discusses lab-cleaning procedures for sampling equipment. Collect an equipment blank (Section II.B) at every tenth sample collected using a discrete depth sampler to assure the sample is not being contaminated by collection equipment.

A peristaltic pump may also be used to collect chemical water samples if the bridge is no more than 25 feet above the water surface. A weighted line attached to the tubing may be lowered into the water to any depth. The pump can pull a surface water sample through the tubing approximately 25 vertical feet. The appropriate sample containers may be filled directly from the outlet tubing attached to the pump. Check the outlet tubing periodically for contamination and replace as necessary.

Since neither the discrete depth sampler nor the peristaltic pump can be sterilized, bacteriological samples cannot be collected using these devices.

3. Water Parameter Measurements

If the cord on the water parameter probe is not long enough to reach from the bridge to the water, a plastic (PVC is acceptable for this use) bucket attached to a rope may be used to collect water for reading water parameters. Rinse the bucket (Section I.H) once with surface water before the water is collected for the water parameter readings. If the bucket gets visibly dirty, muddy or oily, clean the bucket according to the field cleaning procedure in Protocol C. Rinse the probe with surface water from the site before placing it in the bucket to read water parameters.

Fill the bucket with surface water and retrieve it with the rope. If water parameters will be taken from the same bucket used to collect chemical surface water samples, fill chemical sample container before taking water parameter readings. Place calibrated instantaneous water parameter meter(s) in the bucket of surface water, when measuring dissolved oxygen turn on the circulator, and allow the probe to equilibrate before recording results. Some dissolved oxygen probes do not use a circulator, therefore the water does not have to be stirred. For duplicate readings, dump the water from the initial reading and refill the bucket with surface water. Record the results and rinse the probes with rinse water (tap water) after use at each site

Protocol G –Composite Sample Collection

Sampler

Adapted from U.S. Environmental Protection Agency. 2001.

This method is a standardized way of collecting a representative composite sample, ensuring that it does not deteriorate or become contaminated before delivery to the laboratory. Composite samples are most commonly collected as part of NPDES compliance monitoring although it may be appropriate for other types of studies. When collecting a compliance sample, most aspects of monitoring, including sample location and collection method, will be specified in the NPDES permit. If the sample location is not specified in the permit, collect the sample between the last discharge and the receiving water. Generally, mid-depth, center of the flow, in an area with the highest turbulence is the best location for the intake line.

A composite sample is a combined or composited series of discrete, equal samples collected over a temporal or spatial range. Time (temporal) composite samples are made up of a number of discrete samples of equal size collected at equal time intervals into one container. Flow proportional (spatial) composite samples are composed of a number of samples sized relative to the flow. Automatic samplers may be used to collect composite samples either for collecting several aliquots at frequent intervals or to collect continuous samples. Flow proportional samplers are activated and paced by a compatible flow meter. The choice of time composite or flow proportional depends on permit requirements, variability of flow and concentration of pollutants.

Any automatic sampler meeting the following specifications may be used to collect composite samples. It is preferable to use one of TDEC's automatic samplers. However, if field conditions do not allow for the installation of TDECs automatic sampler and the facility's automatic sampler meets these specifications, the facility's sampler may be used.

Automatic Sampler Specifications:

- Automatic sampler must provide refrigeration either by mechanical means or ice.
- Automatic sampler shall be capable of collecting a large enough sample for all parameter analyses (each aliquot must be at least 100-milliliters).
- Automatic sampler must have adjustable sample volume.
- Automatic sampler must provide at least 20 feet of lift.
- Pumping velocity must be at least two feet/second.
- Minimum inside diameter of intake line is ¼ inch.
- No PVC plastic or metal parts may come in contact with the sample water if it is being analyzed for organics or metals.

1. Cleaning and Maintenance

Remove contaminated tubing before cleaning and replace with new tubing before the next sample collection. Thoroughly clean the automatic sampler between uses, (Section I.H) and check for any damage or needed repairs. Inspect the desiccant and batteries and replace if necessary. Test the manual and automatic operation of the automatic sampler to make sure it is operating correctly. Check the pumps function in forward, reverse, automatic, and run the automatic sampler through at least one purge-pump-purge cycle. Compare function against manufacturer's specifications.

Follow manufacturer's instructions to make any needed repairs or calibration changes. Develop calibration and use SOPs for each brand and/or model of automatic sampler used in each EFO. Keep all calibration and repair records in a bound logbook.

2. Safety

Powder-free nitrile gloves must be worn when installing sampling equipment or collecting samples to avoid contamination of the sample and to provide protection from possible health risks. Nitrile gloves should not be assumed to provide adequate protection from acids or hazardous materials.

3. Installation of Automatic Sampler

Power must be available for the entire sampling event. If accessible, the facility's power may be used. If the facility's power is not available, then generator or battery power must be used. Install new tubing (Silastic®, or equal, in the pump and Tygon®, Teflon®, or equal in the sample train) in the automatic sampler before deployment. Collect an equipment blank on the automatic sampler at ten percent of the sites.

Before installation, test the rinse, purge-pump-purge cycle at least once. Also, check the pump volume at least twice using a graduated cylinder. Each aliquot must be at least 100-milliliters. Test flow proportional automatic sampler operation with the flow meter to make certain it is operating properly.

After the automatic sampler and tubing is placed in the proper location, program the sampler. For time composite samples, program the automatic sampler to collect at least 100-milliliters aliquots at the permit specified frequency. For flow proportional samples, program the automatic sampler to collect at least 100-milliliters aliquots at intervals based on the flow.

The final total volume must be sufficient to conduct all required analyses, for either collection method. If possible, install the automatic sampler where specified in the permit. Position the intake to draw wastewater from the mid-channel at mid-depth. If a facility disinfects with chlorine, install the automatic sampler upstream of chlorination.

4. Special Precautions for Metal and Organic Samples

If metal samples are to be collected, rinse the entire automatic sampler with reagent-grade water. Pump about a half a gallon of reagent-grade rinse water through the system and discard. For organic samples, use organic-free reagent-grade water for rinsing and flushing. Pump about one and a half gallons of organic-free reagent-grade water into the composite sample container for distribution into the appropriate blank container.

For metal samples, add nitric acid to the metals blank container for preservation. If the automatic sampler tubing is attached to a metal conduit pipe, install the intake tubing upstream. Wrap the submerged portion of the conduit pipe with a protective barrier such as duct tape.

5. Securing Automatic Sampler

Secure the automatic sampler in such a way as to prevent tampering with the sample. At a minimum, place a lock and signed and dated custody seal on the automatic sampler housing. Some locations may require additional security measures. Custody seals may also be placed on sampling pole and tubing line.

6. Retrieving the Automatic Sampler

When the compositing period has ended, remove the sample from the automatic sampler and thoroughly mix the composite sample. After the sample is well mixed, pour the composite sample into the appropriate, properly preserved sample container(s). Attach a completed sample tag to each sample bottle and complete the Sample Request Form. Write the Site No. (sample ID), two-digit Tennessee County Code, Date, Military Time, Station Location, and Samplers on the sample tag. The primary sampler's name must be on the sample tag. Check the "Composite (Comp.)" box under Designate, mark the sample type and if it contains a preservative. Place the labeled sample bottle in a zip-type bag (optional) and store in a cooler on ice until delivery to the laboratory.

For routine inspections, offer the permittee a split sample. Collect all sampling equipment and perform appropriate cleaning and maintenance on the automatic sampler upon return to the EFO.

Protocol H - Sample Identification Tags

Sampler

Each sample must be correctly identified as to where, when, and by whom it was collected, how it was preserved and what analyses are needed. TDH Environmental Laboratory provides sample tags that have been approved by EPA (Figure 4). If using another TDEC contract laboratory, obtain tags containing the same identification information, from that contract laboratory. Use only non-erasable ink on the sample tags. It is recommended to use waterproof ink or ballpoint pens. Draw one line through any mistake written on the tag. Do not use white out. If a sticker label is attached to the sample tag, it must adhere well enough that it cannot be removed without damaging the tag. Clear packaging tape may be applied over a completed sample tag to assure the sticker will adhere and prevent the ink from smudging. Write legibly. All tags or stickers must include the following identification information.

1. **Billing Code** – Write the billing code of the program area that will pay for the analyses of the sample. Only approved billing codes may be used.

2. **Project/Site No.** – Write the site number or station ID number that uniquely identifies where the sample was collected. This must be filled in. (For example PUNCH001.5GE. See Protocol B for specifics on assigning station numbers.) This is one of two places where the QC type is identified on the tag. (For example, a trip blank on Puncheoncamp Creek is PUNCH001.5GE-TB.)

3. **County** – Write the two-digit Tennessee County Code number, Tennessee County Number (TN CO NO). (See Appendix A for a complete county list.)

4. **Month/Day/Year** – Write the date the sample was collected.

5. **Time** – Record the sample collection time in military time (24-hour clock). Each sample will have a different time of collection to meet the requirements of the sample logger.

6. **Designate** – Indicate whether the sample was a composite (comp.) or grab.

7. **Station Location** – Write the name of the waterbody along with a description of the location at which the sample was taken. Use specific street names and/or crossroads or name of facility with discharge and other features present on maps.

8. **Samplers** – The primary sampler must write their full name. The other samplers should initial.

9. **Preservative** – Mark the appropriate box. No, if the sample is not preserved. Yes, if the sample is preserved.

10. **Analyses** – Place a check or X beside the general type of analysis to be performed on the sample. If the needed analyses are not listed, write in the analyses type on one of the blank lines under Analyses.

11. **Remarks** – Write comments regarding the sample in the remarks box. Write any warnings, such as hazardous, that the analyst may need to be aware in this box. Label quality control samples, such as duplicates, field blanks, trip blanks, or equipment blanks in this box. For bacteriological analyses, list the type of analysis needed and if dilution is required. (See Protocol A for additional information on bacterial analyses.)

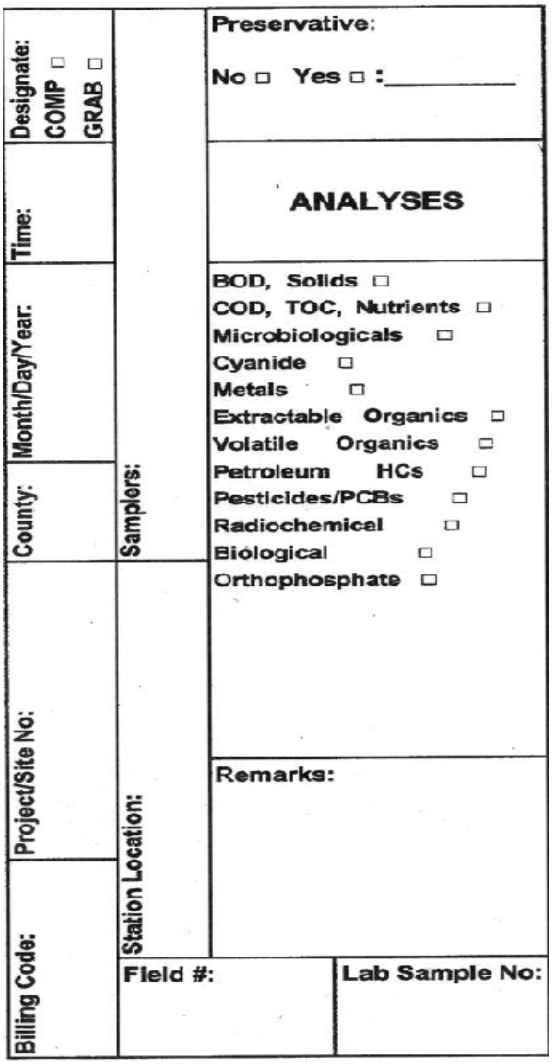

Figure 4: External Sample Tag.

Protocol I - Sample Request Forms

Sampler

Write legibly and complete all information on the Sample Request Forms. Draw one line through any mistake written on the form. Do not use white out. The TDH Environmental Laboratory provides Sample Request Forms, printed on No Carbon Required (NCR) paper. Always use the most recent version of the Sample Request Form. Keep the yellow copy of the Sample Request Form in the project file. Computer generated forms, pre-printed forms, and copied forms can also be used if they are current. A copy of these forms must be kept in the project file. An example of a properly completed sample request form is provided in Appendix A.

If using another TDEC contract laboratory, obtain the appropriate sample request sheets from the contract laboratory. Complete a separate Chain of Custody (Appendix A) if any sample request sheet other than those provided by TDH Environmental Laboratory is used. All sample request forms must include the following information.

1. Header Information

Completely fill out the gray portion in the upper left hand corner of the TDH Environmental Laboratory Sample Request Form (Figure 5).

a. Project/Site No. – Fill in the unique project number, if any, designated by the program area/sampling agency. This does not need to be filled in if no project number is associated with the sample. If there is a designation specified by the EFOs that is used to identify samples and sites, other than the station ID number, that designation goes here.

b. Project Name – Write the specific project name or focus of the field investigation in this blank. If a name is associated with the Project/Site No., write it in this blank. For sites that are part of a larger investigation such as watershed, ambient, 303(d), TMDL, ecoregion, antidegradation, EMAP-WSA write the study name in this blank. This does not need to be filled out if there is no project or study name associated with the sample.

c. Station Number – The station ID number uniquely identifies the location where the sample was collected. Write the station ID in this blank. The station ID number must be completed. (For example PUNCH001.5GE. See Protocol B for assigning station numbers.) This is also where the QC type is identified on the tag. (For example a trip blank on Puncheoncamp Creek is PUNCH001.5GE-TB.)

d. County – Write the designated two-digit Tennessee County Code number, Tennessee County Number, (TN CO NO) in this blank. See Appendix A for a complete county list. Do not use the WPC letter designation.

e. Description – Write the name of the waterbody along with a description of the location at which the sample was taken. Use specific street names and/or crossroad or facility name with discharge and other features present on maps. The description should match the description recorded for that station in the Water Quality Database.

f. Stream Mile – Write the stream mile (or river mile) where the sample was collected. This should be as accurate as possible.

g. Depth – Write the depth at which the water sample was collected if a discrete depth sampler was used to collect the sample. This line may be left blank for subsurface samples.

h. Matrix – Write the sample medium. (For example water, sediment or industrial waste.)

i. Collection Date – Write the date the sample was collected.

j. Time – Write the time the sample was collected recorded in military time (24-hour clock). Each sample will have a different time of collection to meet the requirements of the sample logger.

k. Sampler's Name – Print legibly the first and last name of the primary sampler. The Sampler's Name must be the same name as the "Collected By" signature on the chain of custody and the sample identification tags.

l. Sampling Agency – Write the agency for which the sample was collected. (For example WPC.)

m. Billing Code – Write the TDEC billing code or cost center assigned to various TDEC programs, for purchase of laboratory services. (For example 327.34-20 or 327.34-58061.) Use the same billing code for QC samples as the other samples.

n. If Priority, Date Needed – Only fill out if the analytical results are needed by a particular date such as a program-determined priority or health effect emergency. ASAP is never appropriate. Do not designate a priority date for routine sample collections (the agreed upon turn-around time is 25 business days for chemical sample and 7 business days for bacteriological samples).

o. Send Report To – Write the person's name and address where the sample report is to be sent. Also write the manager's name of the Planning and Standards Section (PAS), Central Office QC coordinator, DWPC for all results from surface waters.

p. Contact Hazard – List any known hazards related to the sample (radiological, chemical, or biological). If there are no known hazards write "unknown" or "none known." Do not write none since there is always the possibility of an unknown hazard.

State of Tennessee – Environmental Laboratories
PLEASE PRINT LEGIBLY

Cypress Creek @ Chulahoma Rd.

PROJECT/SITE NO.		PROJECT NAME	303(d)
STATION NUMBER	CYPRE010.8FA	COUNTY	24
DESCRIPTION	Cypress Creek @ Chulahoma		
STREAM MILE	10.8	DEPTH	MATRIX Water
COLLECTED: DATE	7-11-07	TIME	1110
SAMPLER'S NAME (printed)	Stephanie Hardy		
SAMPLING AGENCY	TDEC - DWPC	BILLING CODE	327.34 58061
IF PRIORITY, DATE NEEDED			
SEND REPORT TO:	Joellyn Brazile E70-M		
	Greg EFO-M NCO		
CONTACT HAZARD	Unknown		

Figure 5: Sample Request Form Header Information

2. Requested Analyses

Designate which analyses need to be performed on the sample by marking an "X" in the box left of the requested analysis (Protocol A) on the Sample Request Form(s) (Appendix A). Choose the needed analyses, but carefully consider cost. Write any special notations, such as requested dilution or low-level analysis, beside the needed analysis.

Minimally sample any 303(d) Listed waterbody for the cause(s) for which it was listed. Ecoregion, ambient, and watershed monitoring stations have a set parameter list (Table 6). Appendix C lists the needed analyses for metal, organic enrichment/DO, nutrient, and pathogen TMDL development. Contact the TMDL manager for additional analyses for TMDL development that may be needed. Consult WPC annual Water Quality Monitoring and Planning Workplan for specific details on planned sampling objectives.

3. Field Determinations

Collect the surface water samples and measure water parameters upstream of the chemical and bacteriological sample area. Use calibrated instantaneous water parameter meters for all field measurements of water parameters (Protocol J). The readings for each parameter are recorded in the appropriate boxes labeled Field Determinations at the bottom left corner of the Chemical Request Form (Figure 6). Record all readings on the Chemical Request Sheet in the units specified on the sheet.

Specific conductivity must be recorded in micromhos per centimeter or microsiemens per centimeter (µmhos/cm or uS/cm), dissolved oxygen in parts per million (ppm), which is equivalent to milligram per liter (mg/l), and temperature in degrees Centigrade (^{o}C). If meter readings are in other units, record the exact readings in the field survey form or field book. If a temperature correction factor must be applied, record the exact readings in the field sheet or book along with the correction factor and record the corrected value on the Chemical Request Sheet. Record the converted readings in the field determination box on the Chemical Request Sheet. Record any additional field parameters such as turbidity or suspended solids under the other category and include units.

Write legibly to avoid errors in data interpretation. Since only one value can be entered in TDH's Laboratory Information Management System (LIMS), record the average of duplicate readings on the Chemical Request Form. Record all readings on the field survey sheet or field book. If the readings are not recorded on the Sample Request Form, send the readings directly to PAS to ensure readings will be entered in the Water Quality Database.

FIELD DETERMINATIONS	Temperature 13.7
pH 7.18	Chlorine, residual
Conductivity 108.3	Other
Dissolved Oxygen 9.69	

Figure 6: Sample Request Form Field Water Parameters

If, after the drift check, the meter was found to be off by more than 0.2 units for pH, temperature or dissolved oxygen calibrated in mg/L or more than 10% for conductivity or dissolved oxygen calibrated to 100 % air saturation, write an "N" before the reading on the field survey sheet for all sites visited between the initial calibration and the drift check. The "N" designates questionable readings. Also, put an "N" before readings on the Chemical Request Form. If the Chemical Request Form has already been turned into the laboratory, fax the field data sheet to PAS and to appropriate laboratory to assure the readings are flagged as questionable when they are entered into the Water Quality Database.

4. Chain of Custody

TDEC's Office of General Counsel requires that the chain of custody (Figure 7) be completed for any sample that has the potential of being used in court, reviewed by the Water Quality Control Board, or involved in state hearings. Therefore, all samples are potentially legal and the integrity of the sample must be beyond question. It is required that the chain of custody be completely filled out and maintained in the project file. See Section II.D for additional information on the chain of custody.

The entire right column of TDH Environmental Laboratories' Chemical and Biological Analysis Request Form(s) is TDEC's official chain of custody. TDEC's Office of General Counsel has approved these forms. If using a TDEC contract laboratory other than TDH Environmental Laboratory, a separate chain of custody must be completed (Appendix A).

The chain of custody follows the sample through collection, transfer, storage, analyses, quality assurance and disposal. Each person responsible for the sample signs, dates, and records the time when samples are transferred into their custody. The TDH Environmental Laboratories maintain the chain of custody as well as a separate Sample Control Log and Manifest and Interlaboratory Chain of Custody for samples transferred between laboratories.

a. Chain of Custody (Required)

(1). Collected by – The primary sampler must sign the first line (first and last name) followed by the date and military time of collection.

Delivered to – Write the name of the person or place where the sample was delivered and the date and military time it arrived each time the sample changes hands. There are three correct options for completing this section:

(a) If the sample is delivered directly to the laboratory, write the lab's name and/or the name of the lab personnel who received the sample in this blank.
(b) If another staff member takes custody of the sample, write their name in this blank.
(c) If a mail, bus, or courier service is used to transport the samples to the laboratory, write the transportation service's name in this blank. The shipping receipt becomes part of the chain of custody documentation and must remain with the chain of custody paperwork

(2). Received by – If the sample is transferred to someone else for delivery to the laboratory, including mail, bus, courier service, or TDEC staff, the recipient must sign their first and last name followed by the date and military time of receipt of the sample.

Delivered to – Write the name of the person or place where the sample was delivered and the date and military time it arrived. See (1).

(3). Received by – If the recipient of the sample gives the sample to a third person for transport to the laboratory, the receiver must sign their first and last name on this line and fill in the date and military time of receipt of the sample.

Delivered to - Write the name of the person or place where the sample was delivered and the date and military time it arrived. See (1).

(4). Received in Lab by – The person in the lab who receives the sample signs their full name followed by the date and military time the sample was received in the lab.

Logged in by – The person in the laboratory who logs in the sample signs their full name followed by the date and military time the sample is logged in.

b. Chain of Custody Additional Information (Required per OGC)

(1). Approximate volume of sample - Write the approximate quantity of all samples collected.

(2). Nearest town or city – Write the name of the nearest town. You can also write the name of the nearest geological feature to the collection point or the latitude and longitude.

(3). Others present at collection – List all people (other than the primary sampler) present when the sample was collected.

(4). Number of other samples collected at same time at this point – Write the total number of additional bacteriological, chemical, biological, algal, or fish samples collected at this station during this sampling event. All analyses requested on the same Sample Request Form are considered one sample. For example, if bacteriological, routine, nutrient, and metals were the only bottles filled at a given site and the Inorganic Analysis Sample Request Form is the only form completed then these bottles are all considered the same sample. However, if organic volatile and biological samples were also collected at the same time the answer would be two additional samples.

(5). Field collection procedure, handling and/or preservation of this sample – If this WPC SOP was followed, write "WPC SOP" in this line. Denote any deviation from WPC protocol here.

(6). Mode of transportation to lab – Record the sample's method of transport to the laboratory (i.e. State vehicle, Greyhound bus, courier etc).

(7). Sample/cooler sealed by – If a custody seal is required (see Protocol C), sign the primary sampler's full name after the cooler has been sealed with a signed and dated custody seal.

(8). Date sample/cooler sealed – Write the date the sample or cooler was sealed with a signed and dated custody seal.

(9). Remarks – Write any special notations here. Include any stream description notes that may affect the sample such as heavy rains, algae, silt etc.

Inorganic Analysis

Laboratory Number
Branch Lab Number

Chain of Custody and Supplemental Information

Only one chain of custody form is required per sample set or point (if all collected at the same time)

1. Collected by Jug Lugger
   Date 08/04/03 Time 11:35
   Delivered to Central Lab
   Date 08/04/03 Time 1435
2. Received by
   Date Time
   Delivered to
   Date Time
3. Received by
   Date Time
   Delivered to
   Date Time
4. Received in Lab by Joe Logsdon
   Date 08/04/03 Time 1435
   Logged in by Joe Logsdon
   Date 08/04/03 Time 1535

Additional Information

1. Approximate volume of sample 1.5 gallons
2. Nearest town or city Murfreesboro, TN
3. Others present at collection Quincy Canwade
4. Number of other samples collected at same time at this point -0
5. Field collection procedure, handling and/or preservation of this sample - WPC SOP
6. Mode of transportation to lab - State Vehicle
7. Sample sealed by Jug Lugger
8. Date sample sealed 08/04/03
9. Remarks

RDA 1627

Figure 7: Sample Request Form Chain of Custody

Protocol J – Instantaneous Field Parameters

Sampler

Adapted from U.S. Environmental Protection Agency. 2002

Measure dissolved oxygen, pH, temperature and conductivity at each chemical or bacteriological monitoring station after samples are collected and before flow is measured or macroinvertebrate samples are collected. Place the probe upstream of where surface water samples were collected. If necessary, samples can be collected at the time of measuring field parameters but it is necessary to measure the field parameters upstream of the collection point. Allow readings to equilibrate before recording measurements. Record the average of appropriate duplicate readings (see QC protocols) on the Chemical Request Form under Field Determinations (This is the value that will be recorded by the lab and entered in the water quality database). Document all duplicate readings on the field survey sheet and/or in the field book. If equipment becomes inoperable in the field, routine watershed and ecoregion monitoring continues without taking field measurements and field parameters are flagged with IF (instrument failure). If monitoring is for TMDL or 303(d) listed waters for DO, pH, temperature, or mining, sampling is rescheduled when properly functioning equipment is available.

Label all meters as property of the State of Tennessee, Department of Environment and Conservation. Assign each meter a distinct identifying designation, (i.e. letter or a portion of the serial number) for calibration, maintenance, and deployment records. Mark each meter with this designation. Record the meter's ID number on the Field Survey Sheet. Multi-probe or individual meters meeting the following minimum specifications may be used (Table 9). Beyond following the instructions in this SOP for calibrating, maintenance, and logging procedures, it is also recommended to refer to manufacturer's instructions.

Table 9: Instantaneous Probe Minimum Specifications.

Parameter	Range	Accuracy	Resolution
Temperature	-5 ^{o}C to 45 ^{o}C	+/- 0.20 ^{o}C	0.1 ^{o}C
Specific Conductivity	0 to 100,000*umhos/cm	+/- 1% of reading	4 digits
pH	2 to 12 units	+/- 0.2 units	0.01 units
Dissolved Oxygen	0 to 20 mg/L	+/- 0.2 mg/L	0.01 mg/L

* Areas of mining or other high conductivity/low pH may need a higher range.

1. **Calibrate Meter(s)** – Meters only need to be calibrated if they are going to be used that week. At the beginning of each week or day or within 24 hours of use, in the EFO lab, calibrate meter(s) for all parameters that will be measured, following the manufacturer's instructions. Conductivity and pH probes are calibrated weekly with a drift check performed daily upon return (or at the end of the sampling period if overnight travel is involved). The drift check can be performed the next morning if time is a factor. The probes must be recalibrated when the drift check is out of the acceptable range, otherwise calibrating these probes once a week is acceptable. A drift check should be performed weekly for temperature. DO probes are to be calibrated each morning of use and at each site where necessary (see # 2). Drift checks for DO probes are not necessary if the meter was recalibrated in the field. If probes are factory calibrated, check readings against the appropriate standards to ensure the calibration is still accurate. Maintain calibration SOPs for each type and/or brand of meter. Keep all calibration records in a bound logbook (Figure 8). Include the date, meter designation, project name/number, initials of calibrator, parameter, standards used, meter reading, and adjustments. Also, record routine maintenance and repairs in the logbook. Some probes must be sent to the manufacturer for calibration. Other probes must be replaced when they no longer maintain their calibration. In these cases, refer to manufacturer's instructions.

   To check the calibration of the temperature probe place an ASTM thermometer in a container of room temperature water large enough to submerge the temperature probe. Place the meter in the water bath and allow it to equilibrate then compare the probe's reading to the thermometer's reading and mathematically adjust the probe's temperature as necessary. Coordinate with TDH laboratory to include the ASTM thermometer in their annual thermometer calibration check against the ASTM certified thermometer. Record this information in the calibration log.

EFO Meter Calibration Log

Date	Meter	Project	Init.	Parameter	Standard	Reading	Adj	Comments
3/6/02	YSI-A	Davis Ck	JEB	Conductivity	142	120	142	Cleaned contacts
3/6/02	YSI-A	Davis Ck	JEB	Conductivity	142	140	NA	Drift Check

Figure 8: Meter Calibration Log

2. **Calibrate DO Probe** – The DO probe must be calibrated using either Winkler Titration (mg/l) or air calibration (% saturation) each morning prior to use. Most probes automatically compensate for temperature changes. Some probes also automatically compensate for pressure changes. An ASTM r calibrated thermometer and/or a handheld barometer must be carried in the field if the probe does not compensate for temperature and/or pressure changes. It is only necessary to recalibrate the probe at sites where there is a significant elevation, pressure or temperature change and the meter does not automatically compensate. A significant change in elevation is 1000 feet. A significant change in pressure is ±20 mm Hg (higher or lower) or when a storm front comes through the area. A significant change in temperature includes any ±5ºC change in temperature (higher or lower). If the DO probe is air calibrated, changes in pressure do affect concentration readings. Record the air calibration at the site in a calibration log in the field to the specified resolution in Table 9.

3. **Probe Placement** – Ideally, measure water parameters after collecting chemical and bacteriological samples and before measuring flow or collecting other samples (i.e. macroinvertebrate, periphyton). Turn on the meter(s) and if there is a DO stirrer, be sure it is activated. Carefully place the meter(s) in the thalweg upstream of the chemical and bacteriological sampling area. Suspend the probe(s) in the water column so it does not touch the bottom. If the water is too shallow to suspend the meter(s), carefully lay it on its side on firm substrate (preferably rock). Do not allow the probe(s) to sink into soft substrate.

   Stand downstream of the probe, being careful not to disturb the substrate in the area of the probe(s). Allow enough time for each reading to stabilize before it is recorded. Depending on the meter, it may take a couple of minutes for dissolved oxygen to equilibrate. Record initial readings in the field notebook or the field survey form to the specified resolution (Table 9). The multi-parameter probe may also be placed in a bucket filled with surface water with the DO stirrer activated and allowed to equilibrate. Rinse the bucket and probe once with surface water before placing probe in the bucket of water.

4. **Duplicate Readings** - Take duplicate measurements at each site. If time is a constraint (short sample holding times or daylight), duplicate readings may be reduced to the first and last site each day. To take a duplicate measurement, lift the probe completely out of the water, wait for the readings to change then return it to the original location or slightly upstream if the sediment was disturbed. Allow the meter to equilibrate before recording readings. If the readings are off by more than 0.2 units for pH, temperature, and DO in mg/L or off by more than 10% for specific conductivity, repeat the procedure until reproducible results are obtained. Record all readings in the field notebook or the field survey form. All results are to be recorded to the resolution specified in Table 9. Rinse the probes with tap water after use at each site to avoid contamination. For water parameters collected with a bucket from a bridge or dock, dump the water from the first sample and refill the bucket with sample water before taking duplicate readings. Place the probe in the bucket, if there is a DO stirrer, be sure it is activated and allow it to equilibrate before recording water parameter readings.

5. **Record Field Parameters** – Document the field parameters in the field determination boxes at the bottom left of the Sample Request Forms (Appendix A). If duplicates were taken, record the average of the acceptable duplicate readings on the Analysis Request Form. Specific conductivity must be recorded in umhos/cm or uS/cm, dissolved oxygen in ppm (mg/l), and temperature in ^{o}C. If meter readings are in other units, record the exact readings in the field survey form or field book and record the converted readings in the field determination box on the Chemical Request Sheet.

6. **Drift Check** – Without post-calibration checks, the accuracy of the water parameter measurements cannot be demonstrated. At the EFO lab, perform a drift check on each meter at the end of the day (or at the end of the trip on multiple night trips) and record results in the logbook (Figure 8). Drift checks can be done in the field as long as you have the proper equipment. To check that the probes have maintained their calibration for pH and conductivity, compare the probe's readings against the appropriate pH, and conductivity standards. Adjust calibration if the probe is going to be used again that week. If the meter's calibration is off by more than 0.2 for pH or more than 10% for conductivity, all readings between the initial calibration and the drift check must be marked as questionable (N). To check that the probes have maintained their calibration for temperature, compare the probe's readings against a standard ASTM thermometer. If the meter's calibration is off by more than 0.2, all the readings between the initial calibration and the drift check must be marked as questionable (N). When the DO probe has been air calibrated in the field due to pressure, elevation or temperature changes, a drift check is unnecessary at the end of the day. If the DO probe was not re-calibrated since leaving the base office, a drift check (Winkler or air calibration) should be performed at the end of the day. If the meter's calibration is off by more than 0.2 mg/L (Winkler) or 10% (air), all readings between the initial calibration and the drift check must be marked as questionable (N). On stream survey sheets and Chemical Request Forms, precede all questionable readings with an "N" (questionable data). If Chemical Request Forms have already been submitted to TDH Environmental Laboratory, notify the Planning and Standards Section in writing (e-mail or fax) of questionable readings so they may be noted in the Water Quality Database.

7. **Other Parameters** – some multi-parameter probes contain sensors for other water quality parameters such as turbidity or suspended solids. If these parameters are also measured, they should be calibrated following manufacturer's specifications prior to use with drift checks performed at the end of each week. Duplicate measurements should be taken at each site and recorded on the stream survey form and/or field book as well as under other field determinations on the sample request form submitted to the laboratory.

Protocol K – Continuous Monitoring Field Parameters

Sampler

Adapted from U.S. Environmental Protection Agency. 2002.

Some sampling objectives will require continuous monitoring of field parameters to document daily fluctuations. Continuous monitoring multi-parameter probes log water quality parameters at regular intervals up to several months. Current studies suggest that probes should be deployed for at least 2 weeks to accurately gauge water parameter fluctuations. The length of deployment will depend on the study objectives. Often diurnal probes are used to monitor water conditions in the low flow months during late summer and early fall. Continuous monitoring probes meeting the following specifications may be used (Table 10).

Table 10: Continuous Monitoring Probe Minimum Specifications

Parameter	Range	Accuracy	Resolution
Temperature	0 °C to 50 °C	+/- 0.2 °C	0.01 °C
Specific Conductivity	0 – 100,000 umhos/cm* or to maximum study requirements	+/- 1% of full scale	4 digits
PH	0 to 14 units	+/- 0.2 units	0.01 units
Dissolved Oxygen	0 to 20 mg/L	+/- 0.2 mg/L	0.01 mg/L

* Areas of mining or other high conductivity/low pH may need a higher range.

The continuous monitoring meter must be completely submerged in water throughout the study to record water parameters. At least 6 inches of water are required to submerge the probe. To produce manageable data, it is recommended that the probe be set to measure water parameter readings no more frequently than every 30 minutes. The sensors are very fragile, so be careful with the probe, especially when the sensor end cover is off for cleaning or maintenance.

Label all meters as property of the State of Tennessee, Department of Environment and Conservation. Assign each meter a distinct identifying number (i.e. serial number, letter, or number) for calibration, maintenance, and deployment records. Mark each meter with this designation.

1. **Pre-deployment calibration Check** – Many continuous monitoring multi-parameter probes are factory calibrated. It is necessary to check the meter's calibration to prove the accuracy has not drifted. The morning of the deployment or within 24 hours prior to deployment, at the EFO lab, check the meter's calibration, following manufacturer's directions. Maintain calibration and maintenance SOPs for each model and/or brand of meter. Keep all calibration check records in a bound logbook (Figure 8). Include the date, meter identification number, project name or number, initials of calibrator, parameter, standards

used, meter reading, and adjustments. Also, record any maintenance or repairs in the logbook. Some probes must be sent to the manufacturer for calibration. Other probes must be replaced when they no longer maintain their calibration. In these cases, refer to manufacturer's instructions.

2. **Initiate Logging –** Either in the EFO office or at the sampling site, follow manufacturer's instructions to connect the continuous monitoring probe to a programmed computer with the sensor cable. Follow the manufacturer's instructions to program the logger and turn on the probe. Change the file name to the Station ID. Check the time, date on the probe, and reset if necessary. Set the probe to record water parameters at regular time intervals according to study needs. Intervals no more frequent than every 30-minutes are recommended to produce a manageable data set and preserve battery life. After the probe has been programmed and the logger has been started, disconnect the sensor cable and prepare the sensors for deployment following the manufacturer's instructions.

3. **Probe Location** - To accurately measure water conditions choose an area of even, non-turbulent flow in which the probe will remain submerged even if the water recedes. At least six continuous inches of water are required for the sensors to read the water parameters accurately. If possible, to avoid vandalism, place the probe in an area out of sight from bridges and roads. Secure the instrument in a location that will give readings representative of ambient conditions.

   To check for maximum diurnal DO fluctuations associated with algae, secure the meter in an area with limited canopy cover. Be aware that if the probe is secured in direct sunlight, the daytime temperatures recorded may be higher than the actual water temperature due to radiant heating. If the study objective is to check diurnal DO swings in the most productive macroinvertebrate habitats, secure the probe in a canopied area. Avoid placing probe in a location that will receive full force of the floodwaters during storm activity (i.e. outside of bends, or bottleneck in streams).

4. **Probe Deployment –** Anchor the probe so it will remain stationary even if high water becomes a problem. Any means of securing the probe may be used, as the details to location are site dependent. In streams with firm substrate, but not bedrock, a good way to secure the probe is to drive a rebar stake into the streambed and attach the sensor to the rebar with stainless steel cable. In bedrock substrate, stabilize the probe with a stainless steel cable or chain attached to a tree root, or boulder.

   Streams with silt and sand substrate pose an especially difficult challenge to avoid burying the probe in sediment. One solution that has been found is to place a concrete block on top of a wooden board and then attach the probe to the top of the concrete block. Another deployment method that works well in deeper waters is to attach the probe securely to a large float such as a boogie board. Then cable or chain the probe to a stable anchor point on the bank and to a weight to keep the floating probe in the channel.

After the probe is securely anchored, camouflage the body of the probe with rocks and branches, but do not cover the sensor end of the probe. Log the probe deployment in the field log (Figure 9) and make careful notes and drawings about where the probe is located. In several weeks, it may be difficult to remember where the probe was placed. It is possible someone else will need to retrieve the probe.

Continuous Monitoring Probe Field Deployment Log

Diurnal Field Log								
Logger Set Out					**Logger Retrieved**			
Station ID	**Probe#**	**Date**	**Time**	**Init.**	**Date**	**Time**	**Init.**	**Comments**
JONES000.1DA	B	7/07/03	0900	JRS	7/21/03	0830	JRS	Lots Algae

Figure 9: Diurnal Field Log

5. **QC Probe Readings –** At every 10th site, anchor a second continuous monitoring probe beside the first to serve as quality control. If time allows it is also recommended that at least one mid-deployment and a pick-up measurement be taken with a calibrated instantaneous probe. (See Section II for additional QC information.)

6. **Probe Retrieval** – After the probe has been deployed the designated time, return to the site where the probe is anchored. Note the probe's location and condition. Take instantaneous readings with a second calibrated probe for comparison. Carefully remove the probe from its anchor and stow it on the bank. Then retrieve the probe anchoring system and prepare the probe sensor for transport per manufacturer's instructions.

   Document probe condition on retrieval, and view readings with caution if the probe was covered in sediment or algae when it was retrieved. Disregard any questionable readings. Usually, the DO will drop markedly when the probe becomes buried. If the probe is not in the same location it was left make careful notes as to where the probe was found and its condition and view the readings with caution. Mark all paperwork with N for uncertain results.

7. **Download Data** – Connect the continuous monitoring probe to the computer via the sensor cable. At the site, open the probe program on the laptop and turn the data logger off. If the probe will be redeployed immediately, download the recorded data onto the laptop computer. Data may be downloaded in transit to the next site. Back-up the data on a floppy disk or CD. If the probe will be returned to the office before it is used again, the data may be downloaded to a programmed desktop computer.

8. **Post Deployment Drift Check** – Check the meter's calibration within 24 hours of returning to the office. Record the post deployment check in a bound logbook. Include the date, meter identification number, project name/number, and initials of the person performing the calibration, parameter, and meter reading. Include any duplicate measurements made with an instantaneous probe. Also, record any maintenance or repairs in the logbook Notify your supervisor if conductivity measurements are off by more than 10% or if dissolved oxygen (mg/l), pH or temperature are off by more than 0.2 units. Mark all associated paperwork with N (uncertain of results). Note that if mid-deployment checks with an instantaneous probe were within acceptable ranges, only those measurements taken between the last duplicate reading and the post-calibration need to be flagged. Follow manufacturer's instructions for re-calibration if necessary.

9. **Clean Probe** – After the post calibration check, clean the sensors very carefully. (The sensors are fragile.) Follow the manufacturer's instructions for cleaning, maintenance, or repairs of the sensors.

10. **Data Interpretation** – Determine which readings reflect water quality. Due to set up time and the reading delay, disregard the initial readings. Review readings for all parameters and check for anomalies. It is possible for the water level to drop and rise back up during the time of deployment. If the probe was not in the same location it was left, carefully review data to determine if it has been removed from the water. Retain original files.

Protocol L – Flow Measurement

Sampler

Adapted from Buchanan, Thomas J. and William P. Somers. 1976.

The accurate measurement of flow is essential to most water pollution control activities. Flow measurement is required for TMDL development, with the exception of pathogen sampling. The flow for TMDL pathogen monitoring is recommended if time permits, otherwise document flow conditions on the field form. (Appendix C). Flow is also required for NPDES and ecoregion reference monitoring (including FECO sites). It is also important for enforcement cases. If holding times are a constraint, flow may be measured later the same day provided there has been no precipitation or change in the flow.

In wadeable waters, measure the flow with an electromagnetic current meter after bacteriological and chemical samples are collected, physical water parameters are measured and before leaving the site. In waters too shallow for use of an electromagnetic current meter or too deep to safely wade, flow may be estimated. For non-wadeable waterbodies, vertical-axis rotor cup type meters may also be used to measure flow. Follow manufacturer's instructions for use, calibration, and maintenance of all flow meters. Record all measurements in tenths of feet.

1. Flow Measurement with Electromagnetic Current Meter

Label each flow meter as property of the State of Tennessee, Department of Environment and Conservation. Assign each meter a unique identification letter or number (i.e. A, B, 1,2, or a portion of the serial number). Mark each meter with this meter identification number. Electromagnetic current meters meeting the following specifications (Table 11) may be used:

Table 11: Electromagnetic Flow Meter Minimum Specifications

Range	Accuracy	Resolution
-0.5 to 20 ft./sec.	+/- 2% of the reading + Zero stability (+/- 0.05 ft./sec.)	0.1 ft./sec.

a. Calibrate Meter - Calibrate the flow meter at the EFO lab, per manufacturer's instructions each week the meter is used. Maintain calibration and maintenance SOPs for each brand and/or model of flow meter. Keep all calibration records in a bound logbook. Include date, meter identification number, project name or number, initials of calibrator, flow measurement, adjustments, and maintenance or repair records in the logbook. Check to be certain the meter is reading in feet per seconds. A zero adjustment is the suggested method to calibrate flow meters. Place the sensor in a five gallon plastic bucket of tap water. Keep it at least three inches away from the sides and bottom of the bucket. To make sure the water is not moving, wait 10-15 minutes after you have positioned the sensor before taking any zero readings. Adjust to zero according to manufacturer's instructions.

b. Select Transect - At the site, select a safely wadeable transect to measure velocity. If possible, the transect should be in a straight area with measurable linear flow. The water surface should be flat, not riffling, with no large obstructions to disrupt the smooth current. The ideal (usually not possible) would be a flat, straight channel with a linear current at an even depth and velocity across the whole channel.

One of the best areas to consider is a run just before a riffle. Avoid braided areas next to large, wet gravel bars, stagnant water, eddies, and bridges. Some channel modifications may make a more uniform channel and be appropriate for measuring flow. Stretch a surveyor's tape (English measurements, marked in tenths of feet), on the selected transect from the left descending bank (LDB) to the right descending bank (RDB) perpendicular to the flow direction. Clamp the ends of the surveyor's tape at the top of each bank to trees and/or stakes. Make sure the surveyor's tape is straight, taut, and close to the water at an even height across the creek.

Record the meter identification number and document where flow measurements were taken. Remove large stones or logs that may interfere with flow and the placement of the wading rod before flow is measured.

c. Measure Flow - Attach the sensor probe to the sensor mount on the wading rod and the sensor cable to the display unit. Turn on the flow meter and make sure it is reading in feet/second (Ft/S). Record all flow information on the Field Flow Measurement Sheet (Appendix A) or in a field notebook.

(1) Record Tape Reading – Record the tape measurement (in tenths of feet) at the left edge of water (LEW). Make the first velocity reading as soon as the water depth is adequate to cover the sensor. Place the wading rod's weighted base flat on the streambed below the surveyors tape and hold it vertically (make sure it is straight). Record the precise tape measurement in the tape-reading column located on the left column (tape reading) of field flow measurement sheet or in the field book. Actual distance measures can be calculated at the office.

(2) Measure Water Depth - Follow the manufacturer's instructions for measuring water depth and placing the sensor at the proper depth in the water column. Record the water depth (in tenths of feet) at this location in the depth column of field flow measurement sheet or in the field book.

(3) Measure Velocity – Adjust the sensor on the wading rod to the proper water depth and point the sensor perpendicular to transect tape. If the water is less than 2.5 feet deep, measure velocity at 0.6 of the total depth. For water deeper than 2.5 feet, measure velocity at both 0.2 and 0.8 of the total water depth and average the reading. Stand downstream and slightly to one side so as not to affect the flow of the current. Allow the readings to equilibrate and then record the average velocity reading in the velocity column on the field flow measurement sheet or in the field book.

(4) Repeat Velocity Measurement – To choose the appropriate spacing of the velocity readings consider the entire stream flow. Ideally, there should be no more than 5 to 10 percent of the total stream flow between each velocity reading. In areas with faster flow, readings will be spaced closer together. Velocity readings may be spaced further apart in areas with slower flow. Readings do not have to be at even increments, however, it is important to accurately record distances and depths.

At the left edge of water (LEW) record the tape reading, water depth and velocity on the next line of the field flow measurement sheet or field notebook. Repeat this procedure for 20 – 30 readings across the stream channel. For streams less than 5 feet wide, take readings at six-inch intervals. The number of measurements necessary for flow is dependent upon the size of the stream. Take the final reading near the right edge of water (REW) at the last place the water is deep enough to cover the sensor. Record the tape reading at the right edge of water (REW). Use additional sheets if more than 30 readings are necessary.

d. QC Flow Measurement - At every 10^{th} site, take a second flow reading in the same transect. Measure QC flow on the same day as the original flow is measured.

If holding times are a constraint, flow and/or QC flow measurements may be taken later the same day if there has been no precipitation or change in flow. After flow has been calculated, if there is more than 10 percent difference between the original and QC flow calculations, designate both flows with an N for uncertainty of accuracy of measurement.

e. Post-Calibration Check – Check the flow meter calibration at the end of each use (minimally once a week) in the EFO lab, according to manufacturer's instruction. Do not clean the sensor before performing post trip calibration check. Record the post trip calibration check in logbook. Flag the results with an N (for questionable) if the reading is off by more than ±0.05 Ft/S. After the post calibration drift check, adjust the calibration as needed following manufacturer's instructions.

f. Calculate Flow - An excel spreadsheet can quickly and accurately calculate total flow. An example of the flow measurement sheet with excel formulas is included in Appendix A. Contact the Planning and Standards Section if an electronic version of this flow calculation spreadsheet is needed. Any method that accurately calculates flow is acceptable.

Translate the tape readings from the field flow measurement sheet to distance from the LDB on the flow measurement sheet. Do not round off tape readings, water depth, or velocity readings. After flow has been calculated, round the total flow to the appropriate significant digit (generally 2 decimal places).

To calculate total flow of the stream or river, use the following formula:

1. Determine the cell width. Each cell width is composed of half of the distance between the previous and the next flow reading, $(W_c-W_a)/2$.
2. Determine the cell area. The cell area is made up of cell width, $(W_c-W_a)/2$, multiplied by the center depth measurement (D_b) of each cell.
3. Calculate cell flow by multiplying the cell area, $D_b[(W_c-W_a)/2]$, times the center velocity reading (V_b) of each cell.
4. Sum all the cell flow readings, $D_b[(W_c-W_a)/2]V_b$, to calculate total flow of the stream or river. This value is the total flow of the stream or river in cubic feet per second (CFS).

$$\Sigma = D_1[(W_2-W_1)/2]V_1 + D_2[(W_3-W_1)/2]V_2 + D_3[(W_4-W_2)/2]V_3 +\ldots+ D_{25}[(W_{25}-W_{24})/2]V_{25}$$

g. QC Data Entry – Have the QC Quality Team Member (Section II.A) or their designee QC data entry and flow calculation before reporting the flow data. Send final flow calculation to PAS.

2. Flow Estimation Float Method

In waters too shallow for use of a current meter or too deep to safely wade, flow may be estimated by the float method. The only items needed to estimate flow are a watch (with seconds reading) or stopwatch, a measurement tool such as a yardstick or tape measure (English units), and something that floats like an orange, cork or piece of wood. Do not use non-biodegradable objects such as plastic bottles.

a. Measure and record the stream width and the stream depth in at least five places. Average the stream depth readings.
b. Multiply the average depth times the stream width to estimate the cross-sectional area.
c. To estimate water velocity, mark a given distance and time how long it takes the floating object to float the measured distance. The object should only take 10-30 seconds to float the given distance.
d. Repeat the velocity estimation at least three times and average the readings to determine mean velocity. When the float times are significantly different from one another, the floating object may be waterlogged. Check the object each time it is used.
e. Since water flows fastest at the surface, multiply the mean velocity by 0.8.
f. To estimate flow, multiply the mean velocity (times 0.8) times the cross-sectional area (average depth times width). Record flow in cubic feet per second (CFS).

Estimated Flow = [Mean Velocity (0.8)] (Avg. Depth) (Width)

3. Flow Estimation Bucket Method

In very small waterways, too small for an object to float, a graduated bucket or cylinder and a watch (with second readings) or a stopwatch may be used to estimate flow. A small temporary dam must be built to channel all flow to a weir or pipe. Capture all of the flow into a graduated bucket or cylinder over a given period of time and measure the amount of water captured. For example if 1.7 liters were captured in 10 seconds, the flow would be 0.17L/Sec. Repeat this measurement at least three times and report the average as the estimated flow. Calculate the flow in CFS. One liter is equivalent to 0.0353 cubic feet. If the average flow was 0.17L/Sec, when calculated into CFS it would be (0.17 x 0.0353) and reported as 0.006CFS.

4. Staff Gage Flow Measurement

If a staff gage is installed at a site, record the water height on the gage. Later plot the staff height on the established flow curve to determine flow or contact the USGS office responsible for the gage and request the flow in cubic feet per second for the corresponding gage height. See USGS protocol for methods and additional information (Buchanan and Somers, 1976). USGS also has real time flow on-line for some gauging stations.

5. **Dye tracers (dilution for "direct" flow measurement in some TMDLs**) – continuous, steady state release of known concentration of dye solution at known release (flow) rate – measure concentration at downstream point in stream at which complete mixing has occurred:

$$Q*C_0 + q*C_1 = (Q + q)*C_2$$

and $Q = q*(C_1 - C_2)/(C_2 - C_0)$

where q = injection rate

C_1 = tracer concentration

C_0 = initial in-stream concentration

C_2 = final concentration

6. **Gauging Station** - A calibrated gauging station (such as USGS) may be used to measure flow if there are no tributaries between the gauge and the sampling point.

Protocol M – Bacteriological (Pathogen) Analyses

Sampler

Adapted from American Public Health Association, American Waterworks Association, Water Environment Federation. 1998.

Due to short holding times and long distances to the laboratory, it a may be more convenient for some EFOs to analyze the bacteriological water samples themselves. EPA has approved the use of the Colilert Method, which utilizes the IDEXX Quanti-Tray®/2000 for total coliform and *E. coli* testing. This method is reproducible but requires certain equipment such as a tray sealer, incubator. If the bacteriological water samples are analyzed at the EFO lab, the results must be within the limits of the method. When the results are outside the limits of the method, the EFO will take corrective action. When the problem cannot be resolved, the EFO must send future bacteriological water samples to the closest TDH laboratory until the problem is resolved.

The Colilert method detects the presence of enzymes produced by total coliform bacteria and *E. coli*. Enzymes produced by total coliform will hydrolyze the substrate and produce a yellow color. If enzymes produced by *E. coli* bacteria are present, they will hydrolyze the substrate and cause the sample to fluoresce under a long-wavelength ultraviolet light. The IDEXX Quanti-Tray®/2000 quantifies the Most Probable Number (MPN) of bacteria detected using the Colilert method.

The media used in this test must be purchased from a commercially available source. Store Colilert media at room temperature and protect it from light. Colilert reagent media have a shelf life of one year. Do not use expired or discolored reagents. Some media lots have been found to auto fluoresce. Whenever a new lot is received, check it for fluorescence under the 366-nm ultraviolet light with a 6-watt bulb and do not use if the media fluoresces.

1. Assign Pathogen Log Number

Log each pathogen sample analyzed at the EFO. Assign a discrete log number to each individual pathogen or bacteriological quality control sample. This will be a unique nine-digit number (i.e. CE0305001) determined in the following manner:

- The first digit represents the office that analyzes the sample (Table 12). The second digit (E) denotes an *E. coli* (bacteriological) sample.

Table 12: Pathogen Log Number Prefixes

Office Abbreviation	EFO Name	Office Abbreviation	EFO Name
CE	Chattanooga EFO	JE	Jackson EFO
LE	Columbia EFO	KE	Knoxville EFO
VE	Cookeville EFO	ME	Memphis EFO
HE	Johnson City EFO	NE	Nashville EFO

- The third and fourth digits represent the year sampled (03 = 2003).
- The fifth and sixth digits represent the month sampled (05 = May).
- The last three digits represent a consecutive number for the number of samples collected that month (001 = the first sample collected in May, 2003).

CP0305001 = the first pathogen sample logged in Chattanooga EFO in May, 2003.

2. Log Pathogen Sample

Maintain a logbook of all bacteriological and quality control samples analyzed at the EFO (Figure 10). The logbook must minimally contain the following information:

- Date sample collected - Formatted: Month-Date-Year (00-00-0000)
- Time sample collected
- Station ID number or appropriate QC designation
- EFO pathogen log number
- Media reagent lot number
- If sample is a QC, add TB for trip blank, FB for field blank, or D for duplicate into the QC column on the Pathogen Log
- Initials of the person who inoculated the sample
- Date sample was inoculated and placed in the incubator - Formatted: Month-Date-Year (00-00-0000)
- Time sample was inoculated
- Temperature of incubator
- Date sample was removed from the incubator and analyzed - Formatted: Month-Date-Year (00-00-0000)
- Time sample was analyzed
- Initials of the person who read the test results (analyzed the sample)
- Number of large and small wells that turned a yellow color equal to or darker than the comparator
- Number of large and small wells that fluoresce under a UV lamp equal to or darker than the comparator
- Record the most probable number Total coliform results from the Quanti-Tray®/2000 MPN table (Table 13)
- Record the most probable number *E. coli* results from the Quanti-Tray®/2000 MPN table (Table 13)
- Record any comments, cautions, QC results or maintenance. Additional comments can be recorded on the following rows.

Pathogen Log

Col. Date	Col. Time	Station ID/ QC ID	EFO Pathogen Log #	Reagent lot #	QC	Inoc. Init.	Date Inoc.	Time inoc	Incub .temp. (^{o}C)	Anal. date	Anal time	Anal .Init.	# yellow Lg/Sm wells (+Total Colif.)	# fluor. Lg/Sm wells (+ *E.coli*)	MPN Total Colif.	MPN *E.coli*	Comments/ Maintenance
05-29-2009	0830	BAKER 008.9WA	HE0305001	472HY		JAL	05-29-2009	1400	34.8	05-30-2009	1405	JAL	46/48	26/40	533	101	
05-29-2009	1000	BWAR 007.4HK	HE0305002	472HY		JAL	05-29-2009	1410	34.8	05-30-2009	1415	JAL	31/48	11/33	142	51	
05-29-2009	1200	RIPLEY 000.1HK	HE0305003	472HY		JAL	05-29-2009	1415	34.8	05-30-2009	1425	JAL	49/44	49/31	1553	649	
05-29-2009	0800	PUNCH 001.5GE	HE0306001	472HY		JAL	05-29-2009	1330	35.2	05-30-2009	1300	JAL	49/40	40/24	1120	140	
06-02-2009	NA	PUNCH 001.5GE	HE0306002	472HY	QC-*P. aerug.*	JAL	06-02-2009	1340	35.2	06-03-2009	1310	JAL	0/0	0/0	0	0	*P.aeruginosa* QC -PASS
05-29-2009	NA	PUNCH 001.5GE	HE0306003	472HY	QC-*K. pneum.*	JAL	06-02-2009	1345	35.2	06-03-2009	1315	JAL	49/36	0/0	866	0	*K.pneumoniae* QC-PASS
06-02-2009	NA	PUNCH 001.5GE	HE0306004	472HY	QC-*E. coli*	JAL	06-02-2009	1350	35.2	06-03-2009	1320	JAL	47/46	40/39	640	198	*E. coli* QC-PASS
05-29-2009	NA	PUNCH 001.5GE	HE0306005	NA	QC-Quanti-Tray sealer	JAL	06-02-2009	1400	NA	06-02-2009	1415	JAL	NA	NA	NA	NA	Quanti-Tray sealer QC-PASS

Figure 10: Pathogen Analyses Log

3. Use of the Colilert 18 or 24 Method Quanti-Tray®/2000

a. Add reagent media to sample. Colilert snap pack reagents are sized for specific volumes of water. Measure the amount of sample water appropriate for the reagent pack. Open the snap pack of media reagent and pour it into the sample water. Place lid on the sterile container and shake it until completely dissolved. Allow any foam to subside before pouring.

b. Carefully pour sample reagent mixture into the Quanti-Tray® without touching the foil tab. Tap tray to remove air bubbles before sealing.

c. Seal Quanti-Tray® according to manufacturer's instructions.

d. Incubate the sample at 35^{o}C +/- 0.5^{o}C for 18 or 24 hours, depending on the Colilert Method.

e. Read test results at 18 or 24 hours. There is a 4 hour period following the 18 or 24 hours incubation period within which the samples may be read.

(1) If no yellow color is observed, the test is negative for total coliform.

(2) If a yellow color lighter than the comparator yellow color is observed incubate the sample for an additional 4 hours, then check the color. If the color has intensified, the sample is positive. If it has not, the test is negative.

(3) If the sample has a yellow color equal to or greater than the comparator, the sample is positive for total coliform. Count the number of yellow large and small wells.

(4) Samples positive for total coliform can be checked for the presence of *E. coli* by placing the Quanti-Tray® in a 6-watt, 365 nm UV lamp and checking for fluorescence. If the fluorescence is equal to or greater than the comparator the sample is positive for *E. coli*. Count the number of large and small fluorescent wells.

f. To determine the coliform and *E. coli* density, compare the number of yellow and/or fluorescing wells to the Most Probable Number (MPN) table provided by the manufacturer (Table 13).

Table 13: Quanti-Tray®/2000 Most Probable Number Table

IDEXX Quanti-Tray®/2000 MPN Table *(per 100ml)*

# Large Wells Positive	# Small Wells Positive																								
	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24
0	<1	1.0	2.0	3.0	4.0	5.0	6.0	7.0	8.0	9.0	10.0	11.0	12.0	13.0	14.1	15.1	16.1	17.1	18.1	19.1	20.2	21.2	22.2	23.3	24.3
1	1.0	2.0	3.0	4.0	5.0	6.0	7.1	8.1	9.1	10.1	11.1	12.1	13.2	14.2	15.2	16.2	17.3	18.3	19.3	20.4	21.4	22.4	23.5	24.5	25.6
2	2.0	3.0	4.1	5.1	6.1	7.1	8.1	9.2	10.2	11.2	12.2	13.3	14.3	15.4	16.4	17.4	18.5	19.5	20.6	21.6	22.7	23.7	24.8	25.8	26.9
3	3.1	4.1	5.1	6.1	7.2	8.2	9.2	10.3	11.3	12.4	13.4	14.5	15.5	16.5	17.6	18.6	19.7	20.8	21.8	22.9	23.9	25.0	26.1	27.1	28.2
4	4.1	5.2	6.2	7.2	8.3	9.3	10.4	11.4	12.5	13.5	14.6	15.6	16.7	17.8	18.8	19.9	21.0	22.0	23.1	24.2	25.3	26.3	27.4	28.5	29.6
5	5.2	6.3	7.3	8.4	9.4	10.5	11.5	12.6	13.7	14.7	15.8	16.9	17.9	19.0	20.1	21.2	22.2	23.3	24.4	25.5	26.6	27.7	28.8	29.9	31.0
6	6.3	7.4	8.4	9.5	10.6	11.6	12.7	13.8	14.9	16.0	17.0	18.1	19.2	20.3	21.4	22.5	23.6	24.7	25.8	26.9	28.0	29.1	30.2	31.3	32.4
7	7.5	8.5	9.6	10.7	11.8	12.8	13.9	15.0	16.1	17.2	18.3	19.4	20.5	21.6	22.7	23.8	24.9	26.0	27.1	28.3	29.4	30.5	31.6	32.8	33.9
8	8.6	9.7	10.8	11.9	13.0	14.1	15.2	16.3	17.4	18.5	19.6	20.7	21.8	22.9	24.1	25.2	26.3	27.4	28.6	29.7	30.8	32.0	33.1	34.3	35.4
9	9.8	10.9	12.0	13.1	14.2	15.3	16.4	17.6	18.7	19.8	20.9	22.0	23.2	24.3	25.4	26.6	27.7	28.9	30.0	31.2	32.3	33.5	34.6	35.8	37.0
10	11.0	12.1	13.2	14.4	15.5	16.6	17.7	18.9	20.0	21.1	22.3	23.4	24.6	25.7	26.9	28.0	29.2	30.3	31.5	32.7	33.8	35.0	36.2	37.4	38.6
11	12.2	13.4	14.5	15.6	16.8	17.9	19.1	20.2	21.4	22.5	23.7	24.8	26.0	27.2	28.3	29.5	30.7	31.9	33.0	34.2	35.4	36.6	37.8	39.0	40.2
12	13.5	14.6	15.8	16.9	18.1	19.3	20.4	21.6	22.8	23.9	25.1	26.3	27.5	28.6	29.8	31.0	32.2	33.4	34.6	35.8	37.0	38.2	39.5	40.7	41.9
13	14.8	16.0	17.1	18.3	19.5	20.6	21.8	23.0	24.2	25.4	26.6	27.8	29.0	30.2	31.4	32.6	33.8	35.0	36.2	37.5	38.7	39.9	41.2	42.4	43.6
14	16.1	17.3	18.5	19.7	20.9	22.1	23.3	24.5	25.7	26.9	28.1	29.3	30.5	31.7	33.0	34.2	35.4	36.7	37.9	39.1	40.4	41.6	42.9	44.2	45.4
15	17.5	18.7	19.9	21.1	22.3	23.5	24.7	25.9	27.2	28.4	29.6	30.9	32.1	33.3	34.6	35.8	37.1	38.4	39.6	40.9	42.2	43.4	44.7	46.0	47.3
16	18.9	20.1	21.3	22.6	23.8	25.0	26.2	27.5	28.7	30.0	31.2	32.5	33.7	35.0	36.3	37.5	38.8	40.1	41.4	42.7	44.0	45.3	46.6	47.9	49.2
17	20.3	21.6	22.8	24.1	25.3	26.6	27.8	29.1	30.3	31.6	32.9	34.1	35.4	36.7	38.0	39.3	40.6	41.9	43.2	44.5	45.9	47.2	48.5	49.8	51.2
18	21.8	23.1	24.3	25.6	26.9	28.1	29.4	30.7	32.0	33.3	34.6	35.9	37.2	38.5	39.8	41.1	42.4	43.8	45.1	46.5	47.8	49.2	50.5	51.9	53.2
19	23.3	24.6	25.9	27.2	28.5	29.8	31.1	32.4	33.7	35.0	36.3	37.6	39.0	40.3	41.6	43.0	44.3	45.7	47.1	48.4	49.8	51.2	52.6	54.0	55.4
20	24.9	26.2	27.5	28.8	30.1	31.5	32.8	34.1	35.4	36.8	38.1	39.5	40.8	42.2	43.6	44.9	46.3	47.7	49.1	50.5	51.9	53.3	54.7	56.1	57.6
21	26.5	27.9	29.2	30.5	31.8	33.2	34.5	35.9	37.3	38.6	40.0	41.4	42.8	44.1	45.5	46.9	48.4	49.8	51.2	52.6	54.1	55.5	56.9	58.4	59.9
22	28.2	29.5	30.9	32.3	33.6	35.0	36.4	37.7	39.1	40.5	41.9	43.3	44.8	46.2	47.6	49.0	50.5	51.9	53.4	54.8	56.3	57.8	59.3	60.8	62.3
23	29.9	31.3	32.7	34.1	35.5	36.8	38.3	39.7	41.1	42.5	43.9	45.4	46.8	48.3	49.7	51.2	52.7	54.2	55.6	57.1	58.6	60.2	61.7	63.2	64.7
24	31.7	33.1	34.5	35.9	37.3	38.8	40.2	41.7	43.1	44.6	46.0	47.5	49.0	50.5	52.0	53.5	55.0	56.5	58.0	59.5	61.1	62.6	64.2	65.8	67.3
25	33.6	35.0	36.4	37.9	39.3	40.8	42.2	43.7	45.2	46.7	48.2	49.7	51.2	52.7	54.3	55.8	57.3	58.9	60.5	62.0	63.6	65.2	66.8	68.4	70.0
26	35.5	36.9	38.4	39.9	41.4	42.8	44.3	45.9	47.4	48.9	50.4	52.0	53.5	55.1	56.7	58.2	59.8	61.4	63.0	64.7	66.3	67.9	69.6	71.2	72.9
27	37.4	38.9	40.4	42.0	43.5	45.0	46.5	48.1	49.6	51.2	52.8	54.4	56.0	57.6	59.2	60.8	62.4	64.1	65.7	67.4	69.1	70.8	72.5	74.2	75.9
28	39.5	41.0	42.6	44.1	45.7	47.3	48.8	50.4	52.0	53.6	55.2	56.9	58.5	60.2	61.8	63.5	65.2	66.9	68.6	70.3	72.0	73.7	75.5	77.3	79.0
29	41.7	43.2	44.8	46.4	48.0	49.6	51.2	52.8	54.5	56.1	57.8	59.5	61.2	62.9	64.6	66.3	68.0	69.8	71.5	73.3	75.1	76.9	78.7	80.5	82.4
30	43.9	45.5	47.1	48.7	50.4	52.0	53.7	55.4	57.1	58.8	60.5	62.2	64.0	65.7	67.5	69.3	71.0	72.9	74.7	76.5	78.3	80.2	82.1	84.0	85.9
31	46.2	47.9	49.5	51.2	52.9	54.6	56.3	58.1	59.8	61.6	63.3	65.1	66.9	68.7	70.5	72.4	74.2	76.1	78.0	79.9	81.8	83.7	85.7	87.6	89.6
32	48.7	50.4	52.1	53.8	55.6	57.3	59.1	60.9	62.7	64.5	66.3	68.2	70.0	71.9	73.8	75.7	77.6	79.5	81.5	83.5	85.4	87.5	89.5	91.5	93.6
33	51.2	53.0	54.8	56.5	58.3	60.2	62.0	63.8	65.7	67.6	69.5	71.4	73.3	75.2	77.2	79.2	81.2	83.2	85.2	87.3	89.3	91.4	93.6	95.7	97.8
34	53.9	55.7	57.6	59.4	61.3	63.1	65.0	67.0	68.9	70.8	72.8	74.8	76.8	78.8	80.8	82.9	85.0	87.1	89.2	91.4	93.5	95.7	97.9	100.2	102.4
35	56.8	58.6	60.5	62.4	64.4	66.3	68.3	70.3	72.3	74.3	76.3	78.4	80.5	82.6	84.7	86.9	89.1	91.3	93.5	95.7	98.0	100.3	102.6	105.0	107.3
36	59.8	61.7	63.7	65.7	67.7	69.7	71.7	73.8	75.9	78.0	80.1	82.3	84.5	86.7	88.9	91.2	93.5	95.8	98.1	100.5	102.9	105.3	107.7	110.2	112.7
37	62.9	65.0	67.0	69.1	71.2	73.3	75.4	77.6	79.8	82.0	84.2	86.5	88.8	91.1	93.4	95.8	98.2	100.6	103.1	105.6	108.1	110.7	113.3	115.9	118.6
38	66.3	68.4	70.6	72.7	74.9	77.1	79.4	81.6	83.9	86.2	88.6	91.0	93.4	95.8	98.3	100.8	103.4	105.9	108.6	111.2	113.9	116.6	119.4	122.2	125.0
39	70.0	72.2	74.4	76.7	78.9	81.3	83.6	86.0	88.4	90.9	93.4	95.9	98.4	101.0	103.6	106.3	109.0	111.8	114.6	117.4	120.3	123.2	126.1	129.2	132.2
40	73.8	76.2	78.5	80.9	83.3	85.7	88.2	90.8	93.3	95.9	98.5	101.2	103.9	106.7	109.5	112.4	115.3	118.2	121.2	124.3	127.4	130.5	133.7	137.0	140.3
41	78.0	80.5	83.0	85.5	88.0	90.6	93.3	95.9	98.7	101.4	104.3	107.1	110.0	113.0	116.0	119.1	122.2	125.4	128.7	132.0	135.4	138.8	142.3	145.9	149.5
42	82.6	85.2	87.8	90.5	93.2	96.0	98.8	101.7	104.6	107.6	110.6	113.7	116.9	120.1	123.4	126.7	130.1	133.6	137.2	140.8	144.5	148.3	152.2	156.1	160.2
43	87.6	90.4	93.2	96.0	99.0	101.9	105.0	108.1	111.2	114.5	117.8	121.1	124.6	128.1	131.7	135.4	139.1	143.0	147.0	151.0	155.2	159.4	163.8	168.2	172.8
44	93.1	96.1	99.1	102.2	105.4	108.6	111.9	115.3	118.7	122.3	125.9	129.6	133.4	137.4	141.4	145.5	149.7	154.1	158.5	163.1	167.9	172.7	177.7	182.9	188.2
45	99.3	102.5	105.8	109.2	112.6	116.2	119.8	123.6	127.4	131.4	135.4	139.6	143.9	148.3	152.9	157.6	162.4	167.4	172.6	178.0	183.5	189.2	195.1	201.2	207.5
46	106.3	109.8	113.4	117.2	121.0	125.0	129.1	133.3	137.6	142.1	146.7	151.5	156.5	161.6	167.0	172.5	178.2	184.2	190.4	196.8	203.5	210.5	217.8	225.4	233.3
47	114.3	118.3	122.4	126.6	130.9	135.4	140.1	145.0	150.0	155.3	160.7	166.4	172.3	178.5	185.0	191.8	198.9	206.4	214.2	222.4	231.0	240.0	249.5	259.5	270.0
48	123.9	128.4	133.1	137.9	143.0	148.3	153.9	159.7	165.8	172.2	178.9	186.0	193.5	201.4	209.8	218.7	228.2	238.2	248.9	260.3	272.3	285.1	298.7	313.0	328.2
49	135.5	140.8	146.4	152.3	158.5	165.0	172.0	179.3	187.2	195.6	204.6	214.3	224.7	235.9	248.1	261.3	275.5	290.9	307.6	325.5	344.8	365.4	387.3	410.6	435.2

09-63235-01

Table 13 continued: Quanti-Tray®/2000 Most Probable Number Table

IDEXX Quanti-Tray®/2000 MPN Table *(per 100ml)*

# Large Wells Positive	# Small Wells Positive																							
	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40	41	42	43	44	45	46	47	48
0	25.3	26.4	27.4	28.4	29.5	30.5	31.5	32.6	33.6	34.7	35.7	36.8	37.8	38.9	40.0	41.0	42.1	43.1	44.2	45.3	46.3	47.4	48.5	49.5
1	26.6	27.7	28.7	29.8	30.8	31.9	32.9	34.0	35.0	36.1	37.2	38.2	39.3	40.4	41.4	42.5	43.6	44.7	45.7	46.8	47.9	49.0	50.1	51.2
2	27.9	29.0	30.0	31.1	32.2	33.2	34.3	35.4	36.5	37.5	38.6	39.7	40.8	41.9	43.0	44.0	45.1	46.2	47.3	48.4	49.5	50.6	51.7	52.8
3	29.3	30.4	31.4	32.5	33.6	34.7	35.8	36.8	37.9	39.0	40.1	41.2	42.3	43.4	44.5	45.6	46.7	47.8	48.9	50.0	51.2	52.3	53.4	54.5
4	30.7	31.8	32.8	33.9	35.0	36.1	37.2	38.3	39.4	40.5	41.6	42.8	43.9	45.0	46.1	47.2	48.3	49.5	50.6	51.7	52.9	54.0	55.1	56.3
5	32.1	33.2	34.3	35.4	36.5	37.6	38.7	39.9	41.0	42.1	43.2	44.4	45.5	46.6	47.7	48.9	50.0	51.2	52.3	53.5	54.6	55.8	56.9	58.1
6	33.5	34.7	35.8	36.9	38.0	39.2	40.3	41.4	42.6	43.7	44.8	46.0	47.1	48.3	49.4	50.6	51.7	52.9	54.1	55.2	56.4	57.6	58.7	59.9
7	35.0	36.2	37.3	38.4	39.6	40.7	41.9	43.0	44.2	45.3	46.5	47.7	48.8	50.0	51.2	52.3	53.5	54.7	55.9	57.1	58.3	59.4	60.6	61.8
8	36.6	37.7	38.9	40.0	41.2	42.3	43.5	44.7	45.9	47.0	48.2	49.4	50.6	51.8	53.0	54.1	55.3	56.5	57.7	59.0	60.2	61.4	62.6	63.8
9	38.1	39.3	40.5	41.6	42.8	44.0	45.2	46.4	47.6	48.8	50.0	51.2	52.4	53.6	54.8	56.0	57.2	58.4	59.7	60.9	62.1	63.4	64.6	65.8
10	39.7	40.9	42.1	43.3	44.5	45.7	46.9	48.1	49.3	50.6	51.8	53.0	54.2	55.5	56.7	57.9	59.2	60.4	61.7	62.9	64.2	65.4	66.7	67.9
11	41.4	42.6	43.8	45.0	46.3	47.5	48.7	49.9	51.2	52.4	53.7	54.9	56.1	57.4	58.6	59.9	61.2	62.4	63.7	65.0	66.3	67.5	68.8	70.1
12	43.1	44.3	45.6	46.8	48.1	49.3	50.6	51.8	53.1	54.3	55.6	56.8	58.1	59.4	60.7	62.0	63.2	64.5	65.8	67.1	68.4	69.7	71.0	72.4
13	44.9	46.1	47.4	48.6	49.9	51.2	52.5	53.7	55.0	56.3	57.6	58.9	60.2	61.5	62.8	64.1	65.4	66.7	68.0	69.3	70.7	72.0	73.3	74.7
14	46.7	48.0	49.3	50.5	51.8	53.1	54.4	55.7	57.0	58.3	59.6	60.9	62.3	63.6	64.9	66.3	67.6	68.9	70.3	71.6	73.0	74.4	75.7	77.1
15	48.6	49.9	51.2	52.5	53.8	55.1	56.4	57.8	59.1	60.4	61.8	63.1	64.5	65.8	67.2	68.5	69.9	71.3	72.6	74.0	75.4	76.8	78.2	79.6
16	50.5	51.8	53.2	54.5	55.8	57.2	58.5	59.9	61.2	62.6	64.0	65.3	66.7	68.1	69.5	70.9	72.3	73.7	75.1	76.5	77.9	79.3	80.8	82.2
17	52.5	53.9	55.2	56.6	58.0	59.3	60.7	62.1	63.5	64.9	66.3	67.7	69.1	70.5	71.9	73.3	74.8	76.2	77.6	79.1	80.5	82.0	83.5	84.9
18	54.6	56.0	57.4	58.8	60.2	61.6	63.0	64.4	65.8	67.2	68.6	70.1	71.5	73.0	74.4	75.9	77.3	78.8	80.3	81.8	83.3	84.8	86.3	87.8
19	56.8	58.2	59.6	61.0	62.4	63.9	65.3	66.8	68.2	69.7	71.1	72.6	74.1	75.5	77.0	78.5	80.0	81.5	83.1	84.6	86.1	87.6	89.2	90.7
20	59.0	60.4	61.9	63.3	64.8	66.3	67.7	69.2	70.7	72.2	73.7	75.2	76.7	78.2	79.8	81.3	82.8	84.4	85.9	87.5	89.1	90.7	92.2	93.8
21	61.3	62.8	64.3	65.8	67.3	68.8	70.3	71.8	73.3	74.9	76.4	77.9	79.5	81.1	82.6	84.2	85.8	87.4	89.0	90.6	92.2	93.8	95.4	97.1
22	63.8	65.3	66.8	68.3	69.8	71.4	72.9	74.5	76.1	77.6	79.2	80.8	82.4	84.0	85.6	87.2	88.9	90.5	92.1	93.8	95.5	97.1	98.8	100.5
23	66.3	67.8	69.4	71.0	72.5	74.1	75.7	77.3	78.9	80.5	82.2	83.8	85.4	87.1	88.7	90.4	92.1	93.8	95.5	97.2	98.9	100.6	102.4	104.1
24	68.9	70.5	72.1	73.7	75.3	77.0	78.6	80.3	81.9	83.6	85.2	86.9	88.6	90.3	92.0	93.8	95.5	97.2	99.0	100.7	102.5	104.3	106.1	107.9
25	71.7	73.3	75.0	76.6	78.3	80.0	81.7	83.3	85.1	86.8	88.5	90.2	92.0	93.7	95.5	97.3	99.1	100.9	102.7	104.5	106.3	108.2	110.0	111.9
26	74.6	76.3	78.0	79.7	81.4	83.1	84.8	86.6	88.4	90.1	91.9	93.7	95.5	97.3	99.2	101.0	102.9	104.7	106.6	108.5	110.4	112.3	114.2	116.2
27	77.6	79.4	81.1	82.9	84.6	86.4	88.2	90.0	91.9	93.7	95.5	97.4	99.3	101.2	103.1	105.0	106.9	108.8	110.8	112.7	114.7	116.7	118.7	120.7
28	80.8	82.6	84.4	86.3	88.1	89.9	91.8	93.7	95.6	97.5	99.4	101.3	103.3	105.2	107.2	109.2	111.2	113.2	115.2	117.3	119.3	121.4	123.5	125.6
29	84.2	86.1	87.9	89.8	91.7	93.7	95.6	97.5	99.5	101.5	103.5	105.5	107.5	109.5	111.6	113.7	115.7	117.8	120.0	122.1	124.2	126.4	128.6	130.8
30	87.8	89.7	91.7	93.6	95.6	97.6	99.6	101.6	103.7	105.7	107.8	109.9	112.0	114.2	116.3	118.5	120.6	122.8	125.1	127.3	129.5	131.8	134.1	136.4
31	91.6	93.6	95.6	97.7	99.7	101.8	103.9	106.0	108.2	110.3	112.5	114.7	116.9	119.1	121.4	123.6	125.9	128.2	130.5	132.9	135.3	137.7	140.1	142.5
32	95.7	97.8	99.9	102.0	104.2	106.3	108.5	110.7	113.0	115.2	117.5	119.8	122.1	124.5	126.8	129.2	131.6	134.0	136.5	139.0	141.5	144.0	146.6	149.1
33	100.0	102.2	104.4	106.6	108.9	111.2	113.5	115.8	118.2	120.5	122.9	125.4	127.8	130.3	132.8	135.3	137.8	140.4	143.0	145.6	148.3	150.9	153.7	156.4
34	104.7	107.0	109.3	111.7	114.0	116.4	118.9	121.3	123.8	126.3	128.8	131.4	134.0	136.6	139.2	141.9	144.6	147.4	150.1	152.9	155.7	158.6	161.5	164.4
35	109.7	112.2	114.6	117.1	119.6	122.2	124.7	127.3	129.9	132.6	135.3	138.0	140.8	143.6	146.4	149.2	152.1	155.0	158.0	161.0	164.0	167.1	170.2	173.3
36	115.2	117.8	120.4	123.0	125.7	128.4	131.1	133.9	136.7	139.5	142.4	145.3	148.3	151.3	154.3	157.3	160.5	163.6	166.8	170.0	173.3	176.6	179.9	183.3
37	121.3	124.0	126.8	129.6	132.4	135.3	138.2	141.2	144.2	147.3	150.3	153.5	156.7	159.9	163.1	166.5	169.8	173.2	176.7	180.2	183.7	187.3	191.0	194.7
38	127.9	130.8	133.8	136.8	139.9	143.0	146.2	149.4	152.6	155.9	159.2	162.6	166.1	169.6	173.2	176.8	180.4	184.2	188.0	191.8	195.7	199.7	203.7	207.7
39	135.3	138.5	141.7	145.0	148.3	151.7	155.1	158.6	162.1	165.7	169.4	173.1	176.9	180.7	184.7	188.7	192.7	196.8	201.0	205.3	209.6	214.0	218.5	223.0
40	143.7	147.1	150.6	154.2	157.8	161.5	165.3	169.1	173.0	177.0	181.1	185.2	189.4	193.7	198.1	202.5	207.1	211.7	216.4	221.1	226.0	231.0	236.0	241.1
41	153.2	157.0	160.9	164.8	168.9	173.0	177.2	181.5	185.8	190.3	194.8	199.5	204.2	209.1	214.0	219.1	224.2	229.4	234.8	240.2	245.8	251.5	257.2	263.1
42	164.3	168.6	172.9	177.3	181.9	186.5	191.3	196.1	201.1	206.2	211.4	216.7	222.2	227.7	233.4	239.2	245.2	251.3	257.5	263.8	270.3	276.9	283.6	290.5
43	177.5	182.3	187.3	192.4	197.6	202.9	208.4	214.0	219.8	225.8	231.8	238.1	244.5	251.0	257.7	264.6	271.7	278.9	286.3	293.8	301.5	309.4	317.4	325.7
44	193.6	199.3	205.1	211.0	217.2	223.5	230.0	236.7	243.6	250.8	258.1	265.6	273.3	281.2	289.4	297.8	306.3	315.1	324.1	333.3	342.8	352.4	362.3	372.4
45	214.1	220.9	227.9	235.2	242.7	250.4	258.4	266.7	275.3	284.1	293.3	302.6	312.3	322.3	332.5	343.0	353.8	364.9	376.2	387.9	399.8	412.0	424.5	437.4
46	241.5	250.0	258.9	268.2	277.8	287.8	298.1	308.8	319.9	331.4	343.3	355.5	368.1	381.1	394.5	408.3	422.5	437.1	452.0	467.4	483.3	499.6	516.3	533.5
47	280.9	292.4	304.4	316.9	330.0	343.6	357.8	372.5	387.7	403.4	419.8	436.6	454.1	472.1	490.7	509.9	529.8	550.4	571.7	593.8	616.7	640.5	665.3	691.0
48	344.1	360.9	378.4	396.8	416.0	436.0	456.9	478.6	501.2	524.7	549.3	574.8	601.5	629.4	658.6	689.3	721.5	755.6	791.5	829.7	870.4	913.9	960.6	1011.2
49	461.1	488.4	517.2	547.5	579.4	613.1	648.8	686.7	727.0	770.1	816.4	866.4	920.8	980.4	1046.2	1119.9	1203.3	1299.7	1413.6	1553.1	1732.9	1986.3	2419.6	>2419.6

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4. Colilert Test Dilutions

If the first time the sample is analyzed, and all of the wells turn yellow and fluoresce, then the *E. coli* and total coliform readings are higher than the maximum undiluted detection limit. The next time the bacteriological sample is collected, dilute the sample with sterile water. Sterilize the appropriate amount of Type I reagent-grade organic-free water in an autoclave and allow it to cool before inoculation or purchase sterilized water.

If an autoclave is not available, sterilized water may be purchased from commercial sources or obtained from TDH Central or Branch Laboratories. Water is only sterile until the bottle is opened. Do not store and reuse sterile water after the bottle has been opened.

Use a sterile disposable pipette or other sterile measuring container to measure the volume of sample and appropriate amount of sterile water to produce the proper dilution (Table 14). Then add reagent media and incubate as above (steps 1-5). Compare the number of yellow and/or fluorescing wells to the MPN table and multiply by the dilution factor to determine the total count.

Table 14: *E. coli* Detection Limit of Colilert Test

Dilution	Factor	Count Range
None	1X	1 to 2,419
1:10	10X	1 to 24,190
1:100	100X	1 to 241,900

5. Colilert Test Quality Control

Perform quality control check on each new lot of media reagent. The manufacturer sells three Quanti-Cult™ or American Type Culture Collection (ATCC) pathogen standards (Table 15) that are used for quality control checks of the reagent media and testing methods. To perform the quality control check, inoculate sterile water with the appropriate Quanti-Cult or ATCC pathogen standards and add the reagent media. Incubate and analyze the sample using the Colilert method. Compare test results to the expected results supplied by the manufacturer.

The analyses are being done correctly if the test results are similar to the expected results. If the results are significantly different, review the testing process and determine the probable origin of the problem. Correct any noted problems and repeat the QC test. For 10 percent of the samples analyzed, run a quality control sample to ensure the samples are being run and interpreted correctly.

Table 15: Quality Control Organisms for Colilert Analyses

Quanti-Cult Organism	ATCC#	Observation	Result
E. coli	25922 or 11775	Yellow, fluorescence	+ Total coliform + *E. coli*
Kiebsiella pneumoniae	31488	Yellow, No fluorescence	+ Total coliform - *E. coli*
Pseudomonas aeruginosa	10145 or 27853	Clear, No Fluorescence	- Total Coliform - *E. coli*

Once a month check the Quanti-Tray® sealer by adding dye to a sample and sealing it. Commercially available dye, bromcresol purple, or 2-3 drops per 100 ml of food coloring may be added to a blank sample and poured into the Quanti-Tray®. Seal the Quanti-Tray® as usual. If dye is observed outside the wells, the seal is leaking and a new sealer should be used.

I.J. Data and Records Management

Data

Minimally all analysis results should be sent to the EFO that collected the samples and the WPC Planning and Standards section. The EFOs should keep sampling data for five years if the data was also sent to the Central Office. If the data is only housed at the EFO, it can be archived after five years. Hard copies of analysis results are stored permanently in the Central Office. Chemical and bacteriological monitoring data and station location information can be found on the Access Water Quality Database. Contact WPC, PAS if assistance is needed in using this database. The master database is stored on the H drive at the central office and is maintained by PAS. The database will be sent to the EFOs and TDH environmental laboratory on a monthly basis.

Records

The Quality Team member (Section II.A) or their designee in each EFO checks that all chemical, bacteriological, and biological stations have been entered with complete information. Chemical and biological stations collected within 0.1 miles of each other where there is no outfall, tributaries or other potential changes to the water quality, will be considered the same station and therefore will have the same station ID. If errors are found or stations are missing from the Access Water Quality Database please notify PAS in writing (email) of the errors so they can be corrected. If stations are missing from the database, include the station name and location, Station ID, county, river mile, latitude/longitude, HUC code, ecoregion, and quad map. If errors are found in the database entries, please include the lab number, Station ID, sample date, and parameter in question. If any analyses results appear incongruent contact the analyzing laboratory and copy PAS for verification of the readings, include laboratory number, station ID, and parameter result in question.

Note, if new stations are set up that will have chemical or bacteriological monitoring, send the station information (Protocol B) to PAS before chemical and bacteriological results are received. It usually takes about a month from the time samples are collected for the results to be received.

II. QUALITY CONTROL AND QUALITY ASSURANCE

The U.S. EPA requires that a centrally planned, directed, and coordinated quality assurance and quality control program be applied to efforts supported by EPA through grants, contracts or other formalized agreements. This time allocation is an essential component of chemical and bacteriological sampling and analyses and is included in the annual work plan. This is not an optional or "as time allows" activity. The validity of all samples hinges on proving that neither the collection method nor the transport contaminated the samples.

II. A. General QC Practices

1. **Quality Team Leader (QC coordinator)** - A centralized chemical and bacteriological QC coordinator is designated with the responsibility of ensuring that all QC protocols are met. This person will be an experienced water quality professional who participates in QC training and planning. Major responsibilities include monitoring QC activities to determine conformance, distributing quality related information, training personnel on QC requirements and procedures, reviewing QA/QC plans for completeness, noting inconsistencies, and signing off on the QA plan and reports. The Planning and Standards section will be responsible for these activities. In addition the deputy director of WPC will discuss QC issues during quarterly visits to each field office.

2. **Quality Team Member (In-house QC officer)** - One WPC staff member in each EFO will be designated as the Quality Team Member (in-house QC officer) by the WPC Manager. The in-house QC officer should be an experienced water quality professional who participates in QC training and planning. This person will be responsible for performing and/or ensuring that quality control is maintained and for coordinating activities with the central Quality Team Leader (QC coordinator). The In-house QC officer is also responsible for maintaining records for all QC samples and recording how many samples (trip, field, and equipment) return a positive reading. If any blank samples have detectable amounts of any analyte, this must be recorded. It is the responsibility of the Quality Team Member to work with field office supervisors, sampling staff, laboratory personnel and the Quality Team Leader to resolve the source of contamination and take corrective action (See Section II.C). Problem resolution should be documented.

3. **Training** – There is no substitute for field experience. All samplers should have at least six months of field experience before selecting sampling sites. For on the job training, new employees should accompany experienced staff for as many different studies and sampling situations as possible. During this training period, the new employee needs to perform all tasks involved in sample collection under the supervision of experienced staff.

II.B. Quality Control Samples

Field blanks, trip blanks and duplicate samples must be collected at a minimum of ten percent of sampling events, defined as every 10^{th} site sampled (this is per EFO not per team). If a run (or site) is rescheduled and it is logistically impossible to change the QC site, it may be necessary to adjust the number of sites collected between QC sites, although 10 percent must be maintained. Whaever sites were collected since the last QC are the ones that are affected by the most recent QC (see example):

Site 1
Site 2
Site 3
Site 4
Site 5
Site 6
Site 7 – QC set reschedule from site 10 applies to sites 1 – 7
Site 8
Site 9
Site 10
Site 11
Site 12
Site 13
Site 14
Site 15
Site 16
Site 17
Site 18
Site 19
Site 20 – QC set applies to sites 8 – 20

A list of the QC blank parameters that should be collected for all field blanks and trip blanks is included in Table 5. Add other parameters outside those specified in table 5 if they are within the group of 10 (e.g. pesticides, BTEX, mercury, $CBOD_5$). Field duplicates should only be those parameters collected for the site where the duplicate is taken. Equipment blanks are needed at every tenth station where an intermediate sampling device such as bucket, bailer, peristaltic pump or Kemmerer is used. A temperature blank to measure cooler temperature must be placed in each cooler if it arrives at the lab more than two hours after collection. If any QC sample is to be analyzed for trace metals or low level mercury, the modified clean technique (Protocol C) must be employed.

All trip, field, and equipment blank water must be Type I organic-free reagent-grade water. TDH laboratories have Type I water filtration systems. This is not the DI tap. Request assistance if needed in locating or using the Type I water filtration system. Wash hands with phosphate-free soap before filling blank water containers and always wear powder-free nitrile gloves while filling the blank containers. Allow the Type I water filtration system to flush at least three minutes before obtaining blank water.

Store blank water for inorganic analysis in unused, pre-cleaned, single-use plastic bottles. For organic analysis, store blank water in glass bottles. Specify organic or inorganic when requesting blank water from the lab. Always keep an ample supply of fresh blank water on hand. The Environmental Laboratory recommends that blank water not be stored more than 28 days. Do not refill old bottles. Obtain a new bottle when replenishing blank water. Never top off stored water even within the 28-day period. Obtain Type I organic-free reagent-grade blank water as close to the sampling event as possible. It is recommended that fresh blank water be obtained weekly. Refrigerate blank water when storing at the EFO and put on ice during transport/sample run.

It is not necessary to sterilize the Type I DI water for bacteriological field and trip blanks. The use of sterilized blank water is recommended as a resolution step if any field office receives lab reports with measurable results in field or trip blanks.

1. **Trip Blanks** – The Trip Blank is used to determine if samples were contaminated during storage or transportation to the laboratory. In the EFO lab, immediately before departing for a sampling trip, fill the appropriate QC sample containers with Type I organic-free reagent-grade water. Wear powder-free nitrile gloves when filling Trip Blanks. Open a new bottle, one that has not been opened prior, of Type I organic-free reagent-grade water in the office and fill the trip blank bottle. Reseal the bottle and carry the jug into the field to prepare the field blank from this same bottle. Any left over water can be used for equipment blanks or rinse water.

   Label the tag and Sample Request Form with the county code, date, military time, sampler, preservative, cost code, project name, and sample type. On the Station Number line of the Sample Request Form and in the Project/Site No Box of the Sample Tag, write "TRIPBLANK", followed by the EFO abbreviation without any spaces between. For example, the Station ID for a trip blank sampled by the Nashville EFO would be "TRIPBLANKNEFO". Specify on the Sample Request Form what parameters need to be analyzed on the blank. Attach a completed sample tag to each sample container and place the trip blank samples in a zip-type colorless plastic bag (optional). Store the Trip Blank QC sample on ice in a clean cooler. The sample is to remain closed the remainder of the trip.

2. **Field Blanks** – The Field Blank is used to determine if contamination originated from sources at the sampling site not associated with the surface water conditions. Near the sampling location, before collecting surface water samples, pour Type I organic-free reagent-grade water from the storage container the trip blank was filled from into the sample container(s). Wear powder-free nitrile gloves when filling Field Blanks. Any left over water can be used for equipment blanks or rinse water.

   Label the tag and Sample Request Form with the county code, date, military time, sampler, preservative, cost code, project name, and sample type. On the Station Number line of the Sample Request Form and in the Project/Site No Box of the Sample Tag, write "FIELDBLANK", followed by the EFO abbreviation without any spaces between. For

example, the Station ID for a field blank sampled by the Nashville EFO would be "FIELDBLANKNEFO". Specify on the Sample Request Form what parameters need to be analyzed on the blank. Attach a completed sample tag to each sample container and place the trip blank samples in a zip-type colorless plastic bag (optional). Store the Field Blank QC sample on ice in a clean cooler. The sample is to remain closed the remainder of the trip.

3. **Duplicate Sample** – The purpose of the duplicate sample is to determine variability of contaminant in surface water samples. Immediately after collecting a sample, fill a second sample container using the same technique. Label the tag and Sample Request Form and complete the station ID, county code, date, military time, sampler, preservative, cost code, project name, and sample type. The time recorded for the duplicate sample should be after the time recorded for the routine sample. Write the station ID-FD on the Station Number line of the Sample Request Form and in the Project/Site No Box of the Sample Tag. Specify on the Sample Request Form what parameters need to be analyzed on the duplicate sample. Attach a completed sample tag to the sample container and place it in a zip-type colorless plastic bag (optional) and store on ice in a clean cooler until delivery to the lab.

4. **Temperature Blank** – A temperature blank is a small bottle filled with water that is placed inside each cooler at the time the samples are stored in the cooler. When the samples are delivered to the laboratory, the temperature of the sample cooler is measured in the temperature blank to ensure it is $6^{o}C$ or less. Samples maintained at higher temperatures are flagged. (Note: If samples are delivered to the laboratory within 2 hours of collection, then temperatures greater than $6^{o}C$ are acceptable.)

5. **Equipment Field Blank** – After reusable equipment such as buckets, bailers, discrete depth samplers, or automatic samplers are cleaned, it is necessary to demonstrate that it is contaminant free. Collect equipment blanks at every 10^{th} sample site where the equipment is used. In the field before collecting the first sample, collect equipment blank by pouring organic-free reagent-grade water into the equipment and collecting the sample into the appropriate sample container.

   Label the tag and Sample Request Form with the county code, date, military time, sampler, preservative, cost code, project name, and sample type. On the Station Number line of the Sample Request Form and in the Project/Site No Box of the Sample Tag, write "EQUIPLANK", followed by the EFO abbreviation without any spaces between. For example, the Station ID for an equipment blank sampled by the Nashville EFO would be "EQUIPBLANKNEFO". Attach the tag to the sample, place the sample in a colorless zip-type plastic bag (optional), and store on ice in a clean cooler until delivery to the laboratory.

6. **Instantaneous Field Water Parameter QC** – Calibrate all probes each week or day before use, depending on which field parameters are to be measured. (If overnight travel is involved, the probes may be calibrated at the beginning of the trip.) Take duplicate water parameter readings at each site. If time is a constraint, duplicate readings may be reduced to the first and last site each day. To take a duplicate reading, lift the probe completely out of

the water, then place it upstream of the original reading and allow the meter to equilibrate before recording results. If the readings are off by more than 0.2 units for pH, temperature, or DO measured in mg/L (or 10% for conductivity or DO measured in % saturation), repeat the procedure until reproducible results are obtained.

Upon return to the EFO Lab, perform a QC drift check on each meter at the end of the day (or at the end of the trip on multiple night trips). If the meter calibration is off by more than 0.2 for pH, DO measured in mg/L or temperature or by more than 10% for conductivity and DO measured in % saturation, all readings between the initial calibration and the drift check must be marked as questionable. On the stream survey sheet and Chemical Request Form, precede questionable readings with an N (questionable data).

If Chemical Request Forms have already been submitted to the laboratory, notify the central office in writing (e-mail or fax) of questionable readings. See Protocol J for additional information on use of instantaneous water parameter meters and reporting of water parameters.

7. **Continuous Water Parameter QC** – At every 10^{th} site, anchor a second continuous monitoring probe beside the first. After the data from both probes have been downloaded, review the readings to ensure that they are within 10 percent of each other. If there is more than 10 percent difference between the two probe readings, notify the supervisor and note on all associated paper work (N) that there was a calibration error. See Protocol K for additional information.

8. **Flow Measurement QC –** Take a second flow measurement at every 10^{th} site. The readings must be taken on the same day and in the same transect. If the original and the QC flow measurements differ by more than 10 percent, make a notation of N (uncertainty of results) on the associated paperwork. See Protocol L for additional information.

II.C. Contaminants Detected in Blank Samples.

When contaminants (values above the mdl) are detected in trip, field, or equipment blanks it is important to investigate the cause of the contamination and initiate corrective action as soon as possible. The Planning and Standards section will coordinate with the laboratory and EFO QC officer about what actions are necessary. A list of QC officers is provided in table 55 of the 106 monitoring QAPP (TDEC, 2011).

The state laboratory will re-analyze WPC and DOE-O trip, field and equipment blanks with measureable and verifiable values above the MQL (i.e. within the calibration curve) and note as such in the comments field below the results entry. The laboratory does not consider estimated values between the mdl and mql as contaminants and these samples are not routinely re-analyzed prior to reporting.

However, 40 CFR, Part 136 (Appendix B) defines the mdl (minimum detection limit) as 99% confidence that the concentration is > 0 (even though the amount cannot be quantified). Therefore, WPC will treat any blank results above the mdl as potential contamination. If the cause of the contamination cannot be isolated to the blank sample, all samples associated with the blank for the parameter of concern will be flagged with an H to designate a "Hit". (Note that the lab flags samples with a B if contaminant is found in the laboratory blank above the MQL).

EFO QC Responsibilities (In-house QC officer)

1. Send field schedule or a list of sites in the order of collection to the PAS QC coordinator so that the sampling events can be associated with QC sets and flagged if necessary. This should be done as often as sampling runs are scheduled, or after changes to schedules have been made. This can be in whatever format is most practical for the field office. Include the date, the list of sample sites (in order collected), and which site the QC set was collected at.

Example for the first week of July for field office xyz:

July 5, 2011 Team a	July 5, 2011 Team b	July 6, 2011 Team c
BEAR006.0AN	BEAR006.0AN	BEAR006.0AN
BEAR007.6AN	BEAR007.6AN	BEAR007.6AN
BFORK004.7AN	BFORK004.7AN	BFORK004.7AN
BGROV000.1AN	BGROV000.1AN - QC	BGROV000.1AN
BRUSH001.0AN	BRUSH001.0AN	BRUSH001.0AN
BUFFA000.3AN	BUFFA000.3AN	BUFFA000.3AN
		CLEAR000.4AN
		CROOK000.5AN -QC

2. The field office QC officer should review blank data as soon as it is received from the lab so decisions can be made about corrective action or the need for resampling. If contaminants (results above the MDL) are found the officer should verify that there were no deviations from protocol including (but not limited to):

a. Source water for blank was from an approved source (Type 1 from Nashville, Jackson or Nashville TDH Environmental Lab).
b. Nitrile gloves were worn when collecting source water for blanks.
c. Nitrile gloves were worn when pouring blank water into sample bottles.
d. Cooler was clean and free of contaminants.
e. Bottle used to store source water was in a new, previous unopened, certified clean container from an approved source.
f. Source water container was stored in a clean area free of dust and dirt. Trip blanks were poured in the same area.
g. Source water had been stored less than 28 days.

3. If deviations from protocol were discovered, take corrective action to avoid potential contamination of future samples.

4. Within 1 week of receipt of contaminated blank results, notify PAS of log number, any deviations from field protocol and corrective action (or that all protocols were followed).

5. If contamination was determined to have only affected blanks and not associated samples, discard blank data, correct problem and repeat QC set. Notify PAS by email of corrective action and provide Lab ID number and which blanks need to be discarded.

6. If contaminated blank resulted in flagged data, determine if more accurate or more defensible data are needed. If so, sampling may need to be repeated. Factors to take into consideration include:

   a. Are flagged parameters slightly above the criterion for that parameter which may result in a determination of impairment? (If it is well above the criterion flag would not affect assessment).
   b. Was sample collected for enforcement, 303(d), reference, or other purpose where questionable data are unacceptable?

PAS QC responsibilities (Central QC Coordinator)

1. Data will be reviewed as received from laboratory. When values above the MDL are observed in any blank, the coordinator will review the information sent by the EFO QC officer to verify that proper procedures were followed and there were no potential sources of field contamination. Coordinator will contact EFO QC officer to obtain information if not received within one week.

2. If potential field contamination was identified, the QC coordinator will flag (H) the parameter where the contaminant was observed for all samples associated with the blank. The source of contamination will be identified in the comment field of the database.

3. If no potential field contamination source was identified, the QC coordinator will contact the laboratory section manager, director and QC officer to verify results, and determine if there were any problems with the analysis. The QC coordinator will also request results from the laboratory instrument blanks for the parameter of concern associated with that sample set to

determine if measurements between the mdl and mql were also found in the laboratory blanks. If so, the QC officer will flag (B) the parameter where the contaminant was observed for all samples associated with the blank. Lab instrument blank values for the parameter of concern will be kept on file with the data report sheet.

4. If neither a lab or field source of contamination can be determined, the parameter where the contaminant was observed for all samples associated with the blank will be flagged with an H. Unknown contamination will be entered in the comment field of the database.

5. If it was determined that the contamination was restricted to the blank sample and would not affect other samples, the blank will be discarded and samples will be associated with the next blank collected.

6. A running record of all contaminated blanks, potential sources of contamination and corrective action will be maintained (Figure 11).

7. Once per month the QC coordinator will review all QC data statewide for each parameter. Any parameter where values above the mdl are found more in more of 10% of blanks or resulted in more than 10% of samples being flagged for that parameter will be investigated by coordination with laboratory and field office QC officers.

Blank contamination resolution

Parameter	Log Number	Date collected	Collected by	Type	Value	mdl/mql	Date analyzed	Analyzed by	Lab Contact	Lab Response	Potential Contaminant Source	Corrective Action	Associated Sample Log Nos.
TP	N00001234	07/01/11	ABC/ NEFO	FB	0.05j	0.001/0.01	07/15/2011	DEF – J	DEF	Data verified; no lab contamination; Lab blanks < mdl.	Gloves not worn when source water collected.	Remind all sample collectors to wear gloves	N00005678 N00006789
Al	N00001	07/01/11	ABC/ NEFO	TB	0.5j	0.1/1.0	07/15/2011	GHI - N	GHI	No response	Unknown	Verify samplers followed protocol	N00005678 N00001234 N00007777

Type = field, trip or equipment
Analyzed by = initials and lab
Collected by = initials and EFO
Lab Contact = who identified the cause of the problem (if the lab could not isolate the cause of the problem, put the initials of who determined that)
Potential Contaminant source = cause of problem, ie sampler did not wear gloves, water not stored properly at EFO, unknown, instrument error, contaminant in lab instrument blank etc.
Corrective Action = what was done to prevent this from happening again, ie retrain field staff, update QSSOP, change water storage location, etc.
Associated Sample Log #'s = Log number of samples with the same parameter included this QC group.

Figure 11: Record of blank water contamination and corrective action.

II.D.

Chain of Custody

TDEC's Office of General Counsel requires that the chain of custody (Figure 7) be completed for any sample that has the potential of being used in court, reviewed by the Water Quality Control Board, or involved in state hearings. Therefore, all samples are potentially legal and the integrity of the sample must be beyond question. The chain of custody is located in the right column of the TDH Environmental Laboratory's Chemical Analyses Forms (Appendix A). If using another TDEC contract lab, a separate chain of custody must be completed (Appendix A). See Protocol I for additional details on completing the Chemical Request Forms.

The chain of custody follows the sample through collection, transfer, storage, analyses, quality assurance, and disposal. The primary sampler must sign (do not print or initial) first and last name in the "Collected By" space followed by date and military time of collection. When the sample is transferred to the next sample custodian, write the name of the person or place receiving the sample and the date and military time of custody transfer. Each custodian of the sample must sign their full name on the "Received By" space with the date and military time the sample was received and complete the "Delivered To" section when it is transferred from their custody. Upon arrival at the laboratory, the person who receives the sample, signs the Received In The Lab By line followed by the date and military time of receipt. When the sample is logged into the LIMS system, the person who logs in the sample, signs and dates the Logged In By line.

Contact the laboratory if samples cannot be delivered during normal hours of operation. If holding times are not an issue, it may be best to secure the samples in a locked area in the EFO and deliver them to the laboratory the next day. It also may be possible to arrange for someone at the laboratory to receive the sample after hours. In either of these scenarios, the laboratory personnel will sign the chain-of-custody. The final and least desirable option for after hour delivery is to have the security guard sign the chain-of-custody and secure the samples. The branch labs do not have security guards on duty, so arrangements must be made ahead of time.

The second half of the chain of custody titled Additional Information is equally important. Complete the bottom half of the right column of the Sample Request Form. Fill out approximate volume of sample, nearest town or city, others present at collection, number of other samples collected at same time at this point, field collection procedure, handling and/or preservation of this sample, and mode of transportation to lab. Sign and date the sample sealed by line and write any remarks or special notations about the sample on the last line.

II.E. Laboratory Detection Limits

In most cases, samples will be sent to the TDH Environmental Laboratory for analyses. This laboratory meets required detection limits for WPC. In special instances (short holding times, grants or collections performed by non-WPC individuals) another TDEC contract laboratory may be used. It is required that the sampler verify that specified detection limits (Appendix B) will be met and that results will be reported in the designated units. The sampler must also insure that both hard copies and electronic database results will be sent to PAS.

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IV. APPENDICES

APPENDIX A

FORMS AND DATA SHEETS

County and State Abbreviations and Code Numbers
TDH Environmental Laboratories Sample Container Request Form
TDH Inorganic Analysis Sample Request Form
TDH Organic Analysis; Base/Neutral/Acid Extractable Sample Request Form
TDH Organic Analysis; Volatiles and Petroleum Hydrocarbons Sample Request Form
Chain of Custody
Field Flow Measurement Sheet
Flow Measurement Sheet (Excel Formulas)

COUNTY AND STATE – Abbreviations and Code Numbers

COUNTY NAME	WPC CO ABBR	TN CO NO	NATIONAL TN FIPS	COUNTY NAME	WPC CO ABBR	TN CO NO	NATIONAL TN FIPS
ANDERSON	**AN**	01	001	LAUDERDALE	**LE**	49	097
BEDFORD	**BE**	02	003	LAWRENCE	**LW**	50	099
BENTON	**BN**	03	005	LEWIS	**LS**	51	101
BLEDSOE	**BL**	04	007	LINCOLN	**LI**	52	103
BLOUNT	**BT**	05	009	LOUDON	**LO**	53	105
BRADLEY	**BR**	06	011	MCMINN	**MM**	54	107
CAMPBELL	**CA**	07	013	MCNAIRY	**MC**	55	109
CANNON	**CN**	08	015	MACON	**MA**	56	111
CARROLL	**CR**	09	017	MADISON	**MN**	57	113
CARTER	**CT**	10	019	MARION	**MI**	58	115
CHEATHAM	**CH**	11	021	MARSHALL	**ML**	59	117
CHESTER	**CS**	12	023	MAURY	**MY**	60	119
CLAIBORNE	**CL**	13	025	MEIGS	**ME**	61	121
CLAY	**CY**	14	027	MONROE	**MO**	62	123
COCKE	**CO**	15	029	MONTGOMERY	**MT**	63	125
COFFEE	**CE**	16	031	MOORE	**MR**	64	127
CROCKETT	**CK**	17	033	MORGAN	**MG**	65	129
CUMBERLAND	**CU**	18	035	OBION	**OB**	66	131
DAVIDSON	**DA**	19	037	OVERTON	**OV**	67	133
DECATUR	**DE**	20	039	PERRY	**PE**	68	135
DE KALB	**DB**	21	041	PICKETT	**PI**	69	137
DICKSON	**DI**	22	043	POLK	**PO**	70	139
DYER	**DY**	23	045	PUTNAM	**PU**	71	141
FAYETTE	**FA**	24	047	RHEA	**RH**	72	143
FENTRESS	**FE**	25	049	ROANE	**RO**	73	145
FRANKLIN	**FR**	26	051	ROBERTSON	**RN**	74	147
GIBSON	**GI**	27	053	RUTHERFORD	**RU**	75	149
GILES	**GS**	28	055	SCOTT	**SC**	76	151
GRAINGER	**GR**	29	057	SEQUATCHIE	**SE**	77	153
GREENE	**GE**	30	059	SEVIER	**SV**	78	155
GRUNDY	**GY**	31	061	SHELBY	**SH**	79	157
HAMBLEN	**HA**	32	063	SMITH	**SM**	80	159
HAMILTON	**HM**	33	065	STEWART	**ST**	81	161
HANCOCK	**HK**	34	067	SULLIVAN	**SU**	82	163
HARDEMAN	**HR**	35	069	SUMNER	**SR**	83	165
HARDIN	**HD**	36	071	TIPTON	**TI**	84	167
HAWKINS	**HS**	37	073	TROUSDALE	**TR**	85	169

COUNTY NAME	WPC CO ABBR	TN CO NO	NATIONAL TN FIPS	COUNTY NAME	WPC CO ABBR	TN CO NO	NATIONAL TN FIPS
HAYWOOD	**HY**	38	075	UNICOI	**UC**	86	171
HENDERSON	**HE**	39	077	UNION	**UN**	87	173
HENRY	**HN**	40	079	VAN BUREN	**VA**	88	175
HICKMAN	**HI**	41	081	WARREN	**WA**	89	177
HOUSTON	**HO**	42	083	WASHINGTON	**WN**	90	179
HUMPHREYS	**HU**	43	085	WAYNE	**WE**	91	181
JACKSON	**JA**	44	087	WEAKLEY	**WY**	92	183
JEFFERSON	**JE**	45	089	WHITE	**WH**	93	185
JOHNSON	**JO**	46	091	WILLIAMSON	**WI**	94	187
KNOX	**KN**	47	093	WILSON	**WS**	95	189
LAKE	**LA**	48	095				
STATE NAME	**WPC ABBR**			**STATE NAME**	**WPC ABBR**		
ALABAMA	**_AL**			MISSISSIPPI	**_MS**		
ARKANSAS	**_AR**			MISSOURI	**_MO**		
GEORGIA	**_GA**			NORTH CAROLINA	**_NC**		
KENTUCKY	**_KY**			VIRGINIA	**_VA**		

Tennessee Department of Health
Environmental Laboratories
Sample Container Request Form

Environmental Field Office (EFO): _____

EFO Contact Person: _____

Contact Phone #: _____

Contact e-mail: _____

Request Date: _____

Environmental Laboratory Contact Information:

Dr. Bob Read	(615)262-6302	bob.read@state.tn.us
Dr. Pramod K. Singh	(615)262-6341	pramod.singh@state.tn.u

Test Description	Container Description	Unit of Measure (UOM)	Quantity per UOM	Request Amount
Inorganic Routines	1 gallon HDPE Bleach Style Jug, **Pre-cleaned**	Case	6	
Inorganic Routines	1000 mL HDPE Oblong Wide Mouth, **Pre-cleaned and Certified**	Case	12	
Nutrients	500 mL HDPE Oblong Wide Mouth with 1 mL Concentrated Sulfuric Acid, **Pre-cleaned and Certified**	Case	24	
Metals	1 L Oblong Wide Mouth with 5 mL 1:1 Nitric Acid **(Trace Metals Grade), Pre-cleaned and Certified**	Case	12	
Mercury	500 mL Oblong Wide Mouth with 2.5 mL 1:1 Nitric Acid, **Pre-cleaned and Certified**	Case	24	
Oil and Grease	32 oz (1000 mL) Clear Straight-Sided Glass Jar with 2 mL Concentrated Sulfuric Acid, **Pre-Cleaned and Certified**	Case	12	
Total Phenol	1 L Amber Boston Round with 2 mL Concentrated Sulfuric Acid, **Pre-cleaned and Certified**	Case	12	
Total Organic Carbon (TOC)	40 mL Glass Vial, Amber with 0.1 mL Concentrated Phosphoric Acid, **Pre-cleaned and Certified**	Case	72	
Volatile Organics (VOA) Water	40 mL Glass Vial, Amber with 1 mL 1:1 Hydrochloric Acid, **Pre-cleaned and Certified**	Case	72	
Volatile Organics (VOA) Soil	4 oz Amber Wide Mouth Glass Jar with septum cap, **Pre-cleaned and Certified**	Case	24	
Extractable Waters	1 L Amber Boston Round Glass Container, **Pre-cleaned and Certified**	Case	12	
Extractable Waters	4 L Amber Glass Jug, **Pre-cleaned and Certified**	Case	12	
Extractable Soils and Metals Soils	16 oz Amber Wide Mouth Glass Jar (Straight-side/Short with cap size approximately 89 mm), **Pre-cleaned and Certified**	Case	12	
Extractable Petroleum Hydrocarbons (EPH)	1 L Amber Boston Round with 5 mL 1:1 Hydrochloric Acid, **Pre-cleaned and Certified**	Case	12	
Extractable Petroleum Hydrocarbons (EPH)	4 L Amber Glass Jug with 20 mL 1:1 Hydrochloric Acid, **Pre-cleaned and Certified**	Case	4	
Glyphosate and Carbamates	40 mL Glass Vial, Amber, **Pre-cleaned and Certified with NO preservative added**	Case	144	
Haloacetic acids, Herbicides and Chloral Hydrate	60 mL Glass Vial, Amber, **Pre-cleaned and Certified with NO preservative added**	Case	144	
Paraquat and Diquat	1000 mL HDPE, Amber Wide Mouth, **Pre-cleaned and Certified with NO preservative added**	Case	24	
Radiochemistry Radon in Water	40 mL Glass Vial, Clear, **Pre-cleaned and Certified with NO preservative added**	Case	72	

State of Tennessee – Environmental Laboratories
PLEASE PRINT LEGIBLY

Inorganic Analysis

PROJECT/SITE NO.	07N-WSP27-3 FD **PROJECT NAME** Watershed
STATION NUMBER	WFBRU000.8CH FD **COUNTY** 11
DESCRIPTION	West Fk Brush Crk @ Knalls Hollow Rd field duplicate
STREAM MILE	10.0 **DEPTH** **MATRIX** water
COLLECTED: DATE	**TIME**
SAMPLER'S NAME (printed)	One or both sampler names here (or one name here and one in bottom Rt area)
SAMPLING AGENCY	WPC **BILLING CODE** 327.34-58051
IF PRIORITY, DATE NEEDED	
SEND REPORT TO:	Joe Holland NEFO-DWPC; Greg Denton, CO - DWPC-PAS
	(lab will not send results unless specific name is listed)
CONTACT HAZARD	None Known (or specify if known)

*	Env. Microbiology
X	coliform, fecal*
	coliform, total*
	strep, fecal*
X	E. Coli*
	Enterococcus*
	Request dilutions for bacti samples
*	**Ambient Parameters**
	COD*
	coliform, fecal
	conductivity*
	hardness, total as $CaCO_3$*
	nitrogen, ammonia
	nitrogen, NO_3 & NO_2
	nitrogen, total Kjeldahl
	phosphate, total
	pH
	residue, dissolved*
	residue, suspended*
	arsenic, As
	cadmium, Cd
	chromium, Cr
	copper, Cu
	lead, Pb
	mercury, Hg
	nickel, Ni
	zinc, Zn

*	General Inorganics
	acidity as $CaCO_3$*
	alkalinity as $CaCO_3$*
	alkalinity, phen. as $CaCO_3$*
	BOD, 5-day*
X	CBOD, 5-day*
	boron
	chloride*
	chlorine, residual*
	chromium, hexavalent
	COD*
	color, apparent*
	color, true*
	conductivity*
	cyanide
	flash point*
	fluoride*
	hardness, Ca as $CaCO_3$*
	hardness, total as $CaCO_3$*
	hydrocarbons, total
	MBAS*
X	nitrogen, ammonia
	nitrogen, nitrate*
	nitrogen, nitrite*
X	nitrogen, NO_3 & NO_2
X	nitrogen, total Kjeldahl
	nitrogen, total organic

	Gen. Inorganics (con't)
	oil and grease
	orthophosphate, total*
	oxygen, dissolved*
	pH
	phenols, total
X	phosphate, total
	residue, dissolved*
	residue, settleable*
X	residue, suspended*
	residue, total*
	silica*
	sulfate*
	sulfide, total*
X	TOC*
	turbidity*
	percent solids
*	**Asbestos**
	bulk asbestos
	other microscopic
*	**Other**

*	Metals
	aluminum,, Al
	antimony, Sb
	arsenic, As
	barium, Ba
	beryllium, Be
	cadmium, Cd
	calcium, Ca
	chromium, Cr
	cobalt, Co
	copper, Cu
	iron, Fe
	lead, Pb
	magnesium, Mg
	manganese, Mn
	mercury, Hg
	nickel, Ni
	potassium, K
	selenium, Se
	silver, Ag
	sodium, Na
	thallium, Tl
	vanadium, V
	Zinc, Zn
*	**TCLP**
	arsenic, As
	barium, Ba
	cadmium, Cd
	chromium, Cr
	lead, Pb
	mercury, Hg
	nickel, Ni
	selenium, Se
	silver, Ag

Laboratory Number
Branch Lab Number
Chain of Custody and Supplemental Information
Only one chain of custody form is required per sample set or point (if all collected at the same time)
1. Collected By Signature (not initials)
Date Time 1300
Delivered to State Lab
Date Time 1500
2. Received by
Date Time
Delivered to
Date Time
3. Received by
Date Time
Delivered to
Date Time
4. Received in Lab by
Date Time
Logged in by
Date Time

Additional Information
1. Approximate volume of sample
~2 Liters + Gallon jug
2. Nearest town or city **Kingston Springs**
3. Others present at collection Ø
Or names other samplers assisting in sampling
4. Number of other samples collected at same time at this point Ø
5. Field collection procedure, handling and/or preservation of this sample **per WPC SOP**
6. Mode of transportation to lab
Locked State vehicle
7. Cooler sealed by
8. Date cooler sealed
9. Remarks
Stream description - Heavy rains, heavy algae, silt

** denotes analyses performed only on water*

FIELD DETERMINATIONS	Temperature
pH	Chlorine, residual
Conductivity	Other turbidity NTU
Dissolved Oxygen	

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Inorganic Analysis

PROJECT/SITE NO.	**PROJECT NAME**
STATION NUMBER	**COUNTY**
DESCRIPTION	
STREAM MILE	**DEPTH** **MATRIX**
COLLECTED: DATE	**TIME**
SAMPLER'S NAME(printed)	
SAMPLING AGENCY	**BILLING CODE**
IF PRIORITY, DATE NEEDED	
SEND REPORT TO:	
CONTACT HAZARD	

*	Env. Microbiology
	coliform, fecal*
	coliform, total*
	strep, fecal*
*	**Ambient Parameters**
	COD*
	coliform, fecal
	conductivity*
	hardness, total as $CaCO_3$*
	nitrogen, ammonia
	nitrogen, NO_3 & NO_2
	nitrogen, total Kjeldahl
	phosphate, total
	pH
	residue, dissolved*
	residue, suspended*
	arsenic, As
	cadmium, Cd
	chromium, Cr
	copper, Cu
	lead, Pb
	mercury, Hg
	nickel, Ni
	zinc, Zn

*	General Inorganics
	acidity as $CaCO_3$*
	alkalinity as $CaCO_3$*
	alkalinity, phen. as $CaCO_3$*
	BOD, 5-day*
	CBOD, 5-day*
	boron
	chloride*
	chlorine, residual*
	chromium, hexavalent
	COD*
	color, apparent*
	color, true*
	conductivity*
	cyanide
	flash point*
	fluoride*
	hardness, Ca as $CaCO_3$*
	hardness, total as $CaCO_3$*
	hydrocarbons, total
	MBAS*
	nitrogen, ammonia
	nitrogen, nitrate*
	nitrogen, nitrite*
	nitrogen, NO_3 & NO_2
	nitrogen, total Kjeldahl
	nitrogen, total organic

	Gen. Inorganics (con't)
	oil and grease
	orthophosphate, total*
	oxygen, dissolved*
	pH
	phenols, total
	phosphate, total
	residue, dissolved*
	residue, settleable*
	residue, suspended*
	residue, total*
	silica*
	sulfate*
	sulfide, total*
	TOC*
	turbidity*
	percent solids
*	**Other**

*	Metals
	aluminum, Al
	antimony, Sb
	arsenic, As
	barium, Ba
	beryllium, Be
	cadmium, Cd
	calcium, Ca
	chromium, Cr
	cobalt, Co
	copper, Cu
	iron, Fe
	lead, Pb
	magnesium, Mg
	manganese, Mn
	mercury, Hg
	nickel, Ni
	potassium, K
	selenium, Se
	silver, Ag
	sodium, Na
	thallium, Tl
	vanadium, V
	zinc, Zn
*	**TCLP**
	arsenic, As
	barium, Ba
	cadmium, Cd
	chromium, Cr
	lead, Pb
	mercury, Hg
	nickel, Ni
	selenium, Se
	silver, Ag

denotes analyses performed only on water

FIELD DETERMINATIONS	Temperature
pH	Chlorine, residual
Conductivity	Other
Dissolved Oxygen	

Laboratory Number

Branch Lab Number

Chain of Custody and Supplemental Information

Only one chain of custody form is required per sample set or point (if all collected at the same time)

1. Collected by
   Date Time
   Delivered to
   Date Time
2. Received by
   Date Time
   Delivered to
   Date Time
3. Received by
   Date Time
   Delivered to
   Date Time
4. Received in Lab by
   Date Time
   Logged in by
   Date Time

Additional Information

1. Approximate volume of sample
2. Nearest town or city
3. Others present at collection
4. Number of other samples collected at same time at this point
5. Field collection procedure, handling and/or preservation of this sample
6. Mode of transportation to lab
7. Sample sealed by
8. Date sample sealed
9. Remarks

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PROJECT/SITE NO.	**PROJECT NAME**
STATION NUMBER	**COUNTY**
DESCRIPTION	
STREAM MILE	**DEPTH** **MATRIX**
COLLECTED: DATE	**TIME**
SAMPLER'S NAME(printed)	
SAMPLING AGENCY	**BILLING CODE**
IF PRIORITY, DATE NEEDED	
SEND REPORT TO:	
CONTACT HAZARD	

*	**NPDES** Extractables
	butylbenzylphthalate
	bis(2-ethylhexyl)phthalate
	di-n-butylphthalate
	di-n-octylphthalate
	diethylphthalate
	dimethylphthalate
	n-nitrosodimethylamine
	n-nitrosodiphenylamine
	n-nitrosodi-n-propylamine
	isophorone
	nitrobenzene
	2,4-dinitrotoluene
	acenaphthene
	acenaphthylene
	anthracene
	benzo(a)anthracene
	benzo(a)pyrene
	benzo(b)fluoranthene
	benzo(g,h,i)perylene
	benzo(k)fluoranthene
	chrysene
	dibenzo(a,h)anthracene
	fluoranthene
	fluorene
	indeno(1,2,3-c,d)pyrene
	naphthalene
	phenanthrene
	pyrene
	bis(2-chloroethyl)ether
	bis(2-chloroethoxy)methane
	bis(2-chloroisopropyl)ether
	4-bromophenylphenylether
	4-chlorophenylphenylether
	hexachlorocyclopentadiene
	hexachlorobutadiene
	hexachlorobenzene
	hexachloroethane
	1,2,4-trichlorobenzene
	2-chloronaphthalene
	4-chloro-3-methyl phenol

*	**NPDES** Extractables(con't)
	2-chlorophenol
	2,4-dichlorophenol
	2,4-dimethylphenol
	2,4-dinitrophenol
	4,6-dinitro-o-cresol
	2-nitrophenol
	4-nitrophenol
	pentachlorophenol
	phenol
	2,4,6-trichlorophenol
*	**TCL** Semivolatiles
	acenaphthene
	acenaphthylene
	anthracene
	benzo(a)anthracene
	benzo(a)pyrene
	benzo(b)fluoranthene
	benzo(g,h,i)perylene
	benzo(k)fluoranthene
	benzoic acid
	benzyl alcohol
	bis(2-chloroethoxy)methane
	bis(2-chloroethyl) ether
	bis(2-chloroisopropyl)ether
	bis(2-ethylhexyl)phthalate
	4-bromophenylphenylether
	butylbenzylphthalate
	4-chloroaniline
	4-chloro-3-methyl phenol
	2-chloronaphthalene
	4-chlorophenylphenylether
	chrysene
	di-n-butylphthalate
	di-n-octylphthalate
	dibenzo(a,h)anthracene
	dibenzofuran
	3,3'-dichlorobenzidine
	2,4-dichlorophenol
	diethylphthalate
	2,4-dimethylphenol

*	**TCL** Semivolatiles
	dimethylphthalate
	4,6-dinitro-2-methylphenol
	2,4-dinitrophenol
	2,4-dinitrotoluene
	2,6-dinitrotoluene
	fluoranthene
	fluorene
	hexachlorobenzene
	hexachlorobutadiene
	hexachlorocyclopentadiene
	hexachloroethane
	indeno(1,2,3-cd)pyrene
	isophorone
	2-methylnaphthalene
	2-methylphenol
	4-methylphenol
	n-nitrosodiphenylamine
	n-nitroso-n-dipropylamine
	naphthalene
	2-nitroaniline
	3-nitroaniline
	4-nitroaniline
	nitrobenzene
	2-nitrophenol
	4-nitrophenol
	pentachlorophenol
	phenanthrene
	phenol
	pyrene
	1,2,4-trichlorobenzene
	2,4,5-trichlorophenol
	2,4,6-trichlorophenol
*	**Nitrobodies**
	RDX
	2,4,6-TNT
	2,4-dinitrotoluene
	2,6-dinitrotoluene
	nitrobenzene
	1,3,5-TNB

*	**TCLP** Semivolatiles
	chlordane
	o-cresol
	m-cresol
	p-cresol
	cresol
	2,4-D
	2,4-dinitrotoluene
	endrin
	heptachlor
	heptachlor epoxide
	hexachlorobenzene
	hexachlorobutadiene
	hexachloroethane
	lindane
	methoxychlor
	nitrobenzene
	pentachlorophenol
	pyridine
	toxaphene
	2,4,5-trichlorophenol
	2,4,6-trichlorophenol
	2,4,5-TP (Silvex)
*	**Pesticides/PCBs**
	aldrin
	alpha-BHC
	beta-BHC
	delta-BHC
	gamma-BHC (lindane)
	technical chlordane
	alpha-chlordane
	gamma-chlordane
	4,4'-DDD
	4,4'-DDE
	4,4'-DDT
	dieldrin
	endosulfan I
	endosulfan II
	endosulfan sulfate
	endrin
	endrin aldehyde
	endrin ketone
	heptachlor
	heptachlor epoxide
	toxaphene
	methoxychlor
	PCB 1016/1242
	PCB 1221
	PCB 1232
	PCB 1248
	PCB 1254
	PCB 1260
	PCB 1262

Organic Analysis
Base/Neutral/Acid Extractables

Laboratory Number

Branch Lab Number

Chain of Custody and Supplemental Information

Only <u>one</u> chain of custody form is required per sample set or point (if all collected at the same time)

1. Collected by
   Date Time
   Delivered to
   Date Time
2. Received by
   Date Time
   Delivered to
   Date Time
3. Received by
   Date Time
   Delivered to
   Date Time
4. Received in Lab by
   Date Time
   Logged in by
   Date Time

Additional Information

1. Approximate volume of sample
2. Nearest town or city
3. Others present at collection
4. Number of other samples collected at same time at this point
5. Field collection procedure, handling and/or preservation of this sample
6. Mode of transportation to lab
7. Sample sealed by
8. Date sample sealed
9. Remarks

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Organic Analysis

Volatiles and Petroleum Hydrocarbons

PROJECT/SITE NO.	PROJECT NAME
STATION NUMBER	COUNTY
DESCRIPTION	
STREAM MILE	DEPTH MATRIX
COLLECTED: DATE	TIME
SAMPLER'S NAME(printed)	
SAMPLING AGENCY	BILLING CODE
IF PRIORITY, DATE NEEDED	
SEND REPORT TO:	
CONTACT HAZARD	

*	NPDES Volatiles - 624	*	TCL Volatiles - 8260A	*	TCLP Volatiles
	Bromoform		Chloromethane		Benzene
	Bromodichloromethane		Bromomethane		Carbon tetrachloride
	Carbon Tetrachloride		Vinyl chloride		Chlorobenzene
	Chlorobenzene		Chloroethane		Chloroform
	Chloroethane		Methylene chloride		1,2-Dichloroethane
	2-Chloroethylvinyl ether		Acetone		1,1-Dichloroethane
	Chloroform		Carbon disulfide		Methyl ethyl ketone
	Chloromethane		1,1-Dichloroethene		Tetrachloroethene
	Dibromochloromethane		1,1-Dichloroethane		Trichloroethene
	1,2-Dichlorobenzene		Cis-1,2-dichloroethene		Vinyl chloride
	1,3-Dichlorobenzene		Trans-1,2-dichloroethene	*	BTEX - 8260A - UST
	1,4-Dichlorobenzene		1,2-Dichloroethane		Benzene
	Dichlorodifluoromethane		Chloroform		Toluene
	1,1-Dichloroethane		2-Butanone		Ethyl benzene
	1,2-Dichloroethane		1,1,1-Trichloroethane		o-Xylene
	1,1-Dichloroethene		Carbon tetrachloride		m-Xylene
	Cis-1,2-dichloroethene		Vinyl acetate		p-Xylene
	Trans-1,2-dichloroethene		Bromodichloromethane		Methyl t-butyl ether
	1,2-Dichloropropane		1,2-Dichloropropane		Diisopropyl ether
	Cis-1,3-dichloropropene		Cis-1,3-dichloropropene	*	TPH by GC
	Trans-1,2-dichloroethene		Trichloroethene		Gasoline Range Organics
	Methylene chloride		Dibromochloromethane		Diesel Range Organics
	1,1,2,2-Tetrachloroethane		1,1,2-Trichloroethane		Oil Range Organics
	Tetrachloroethene		Benzene	*	Other
	1,1,1-Trichloroethane		Trans-1,3-dichloropropene		
	1,1,2-Trichloroethane		Bromoform		
	Trichloroethene		4-Methyl-2-pentanone		
	Trichlorofluoromethane		2-Hexanone		
	Vinyl chloride		Tetrachloroethene		
	Benzene		Toluene		
	Ethylbenzene		1,1,2,2-Tetrachloroethane		
	Toluene		Chlorobenzene		
	o-Xylene		Ethyl benzene		
	m-Xylene		Styrene		
	p-Xylene		o-Xylene		
			m-Xylene		
			p-Xylene		

Laboratory Number

Chain of Custody and Supplemental Information

Only one chain of custody form is required per sample set or point (if all collected at the same time)

1. Collected by
   Date Time
   Delivered to
   Date Time
2. Received by
   Date Time
   Delivered to
   Date Time
3. Received by
   Date Time
   Delivered to
   Date Time
4. Received in Lab by
   Date Time
   Logged in by
   Date Time

Additional Information

1. Approximate volume of sample
2. Nearest town or city
3. Others present at collection
4. Number of other samples collected at same time at this point
5. Field collection procedure, handling and/or preservation of this sample
6. Mode of transportation to lab
7. Sample sealed by
8. Date sample sealed
9. Remarks

RH-3843 (rev. 11/97) RDA 1503

Chain of Custody

PROJECT/SITE NO.	PROJECT NAME
STATION NUMBER	COUNTY
DESCRIPTION	
STREAM MILE	MATRIX
COLLECTED: DATE	TIME
SAMPLER'S NAME (printed)	
SAMPLING AGENCY	
Laboratory Number	Branch Lab Number

CHAIN OF CUSTODY

Only one chain of custody form is required per sample set or point (if all collected at the same time)	
1. Collected by	
Date	Time
Delivered to	
Date	Time
2. Received by	
Date	Time
Delivered to	
Date	Time
3. Received by	
Date	Time
Delivered to	
Date	Time
4. Received in Lab by	
Date	Time
Logged in by	
Date	Time

ADDITIONAL INFORMATION

1. Approximate volume of sample
2. Nearest town or city
3. Others present at collection
4. Number of other samples collected at same time at this point.
5. Field collection procedure, handling and/or preservation of this sample
6. Mode of transportation to lab
7. Sample sealed by
8. Date sample sealed
9. Remarks

From PH-3011 (rev 10/98), PH-3013 (rev 11/97), and PH-3014 (rev 1/96)

Field Flow Measurement Sheet

Station ID: _____ Date: _____
Stream Name: _____ Time: _____
Location: _____ Previous Rain: _____
Samplers: _____ Flow Meter ID: _____

Tape Reading (feet)	**Depth** (feet)	**Velocity** (ft/sec)	**Distance** (feet) (from LDB)	**Cell Width** (feet)	**Comments**
1.					
2.					
3.					
4.					
5.					
6.					
7.					
8.					
9.					
10.					
11.					
12.					
13.					
14.					
15.					
16.					
17.					
18.					
19.					
20.					
21.					
22.					
23.					
24.					
25.					
26.					
27.					
28.					
29.					
30.					

Flow Measurement Sheet (Excel Formulas)

Station ID:	**Date:**	**Peak Velocity =**	**MAX(C10:C41)**
Stream Name:	**Time:**	**Avg. Velocity =**	**AVERAGE(C10:C41)**
Location:	**Previous Rain:**	**Max. Depth =**	**MAX(B10:B41)**
Sampler:	**Flow meter ID#:**	**Avg. Depth =**	**AVERAGE(B10:B41)**

Tape Reading (in order)	Depth (feet)	Velocity (ft/sec.)	Distance (ft) (from LDB)	Cell Width (feet)	Flow/Cell (cfs)
			0	=(D11-D10)/2	=B10*E10*C10
			=A11-A10	=(D12-D10)/2	=B11*E11*C11
			=A12-A10	=(D13-D11)/2	=B12*E12*C12
			=A13-A10	=(D14-D12)/2	=B13*E13*C13
			=A14-A10	=(D15-D13)/2	=B14*E14*C14
			=A15-A10	=(D16-D14)/2	=B15*E15*C15
			=A16-A10	=(D17-D15)/2	=B16*E16*C16
			=A17-A10	=(D18-D16)/2	=B17*E17*C17
			=A18-A10	=(D19-D17)/2	=B18*E18*C18
			=A19-A10	=(D20-D18)/2	=B19*E19*C19
			=A20-A10	=(D21-D19)/2	=B20*E20*C20
			=A21-A10	=(D22-D20)/2	=B21*E21*C21
			=A22-A10	=(D23-D21)/2	=B22*E22*C22
			=A23-A10	=(D24-D22)/2	=B23*E23*C23
			=A24-A10	=(D25-D23)/2	=B24*E24*C24
			=A25-A10	=(D26-D24)/2	=B25*E25*C25
			=A26-A10	=(D27-D25)/2	=B26*E26*C26
			=A27-A10	=(D28-D26)/2	=B27*E27*C27
			=A28-A10	=(D29-D27)/2	=B28*E28*C28
			=A29-A10	=(D30-D28)/2	=B29*E29*C29
			=A30-A10	=(D31-D29)/2	=B30*E30*C30
			=A31-A10	=(D32-D30)/2	=B31*E31*C31
			=A32-A10	=(D33-D31)/2	=B32*E32*C32
			=A33-A10	=(D34-D32)/2	=B33*E33*C33
			=A34-A10	=(D35-D33)/2	=B34*E34*C34
			=A35-A10	=(D36-D34)/2	=B35*E35*C35
			=A36-A10	=(D37-D35)/2	=B36*E36*C36
			=A37-A10	=(D38-D36)/2	=B37*E37*C37
			=A38-A10	=(D39-D37)/2	=B38*E38*C38
			=A39-A10	=(D40-D38)/2	=B39*E39*C39
			=A40-A10	=(D41-D39)/2	=B40*E40*C40
			=A41-A10	=(D41-D40)/2	=B41*E41*C41

Stream Width =	**=D41**	**Avg. Flow (cfs) =**	**=SUM(F10:F41)**
		(Round flow to 2 decimal places)	

APPENDIX B

TESTS, CONTAINERS, HOLDING TIMES, and LABORATORY MDLs

TDH Bacteriological Analyses Available
TDH Routine Analyses Available
TDH Nutrient Analyses Available
TDH Metal Analyses Available
TDH Miscellaneous Inorganic Analyses Available
TDH Organic Analyses Available
Laboratory MDLs for Metals
Laboratory MDLs for Non-Metals (Inorganics)
Laboratory MDLs for Pesticides
Laboratory MDLs for PCBs
Laboratory MDLs for PAHs
Laboratory MDLs for Semivolitiles
Laboratory MDLs for Volitiles

TDH Bacteriological Analyses Available

Test	Holding Time	Container	Preservative
Coliform, fecal	6 hours	Two 250 mL plastic	Sodium Thiosulfate ($Na_2S_2O_3$). Bottles are labeled with preparation date and expiration date. Do not use expired bottles.
Coliform, total	6 hours		
*E. coli**	6 hours		
Strep, fecal	6 hours		

*Only one bottle is needed if *E. coli* is the analysis requested.
Store on ice at $\leq 10^{o}$C.

TDH Routine Analyses Available

Test	Holding Time	Container	Preservative
Acidity	14 days	1 liter plastic*	None
Alkalinity	14 days		
Alkalinity, phen.	14 days		
BOD, 5-day	48 hours		
CBOD, 5-day	48 hours		
Chloride	28 days		
Chlorine, residual	Test immed.		
Chromium, hexavalent	24 hours		
Conductivity	28 days		
Fluoride	28 days		
Nitrogen, nitrate	48 hours		
Nitrogen, nitrite	48 hours		
Orthophosphate, total	48 hours		
Oxygen, dissolved	Field		
pH	Field		
Silica	28 days		
Sulfate	28 days		
Turbidity	48 hours		
MBAS	48 hours	1 gallon plastic	
Color, apparent	48 hours		
Color, true	48 hours		
Residue, dissolved	7 days		
Residue, suspended	7 days		
Residue, settleable	48 hours		
Residue, total	7 days		

All plastics are single-use. Store on ice at $\leq 6^{o}$C.
No preservative is needed for Routine Samples.
*If multiple analyses are needed, collect 1 gallon of sample to assure adequate volume is available for analyses and QC. Contact TDH Lab if assistance is needed to determine how much sample to collect.

TDH Nutrient Analyses Available

Test	Holding Time	Container	Preservative
COD	28 days	500 mL plastic	1 mL sulfuric acid (H_2SO_4)
Nitrogen, ammonia	28 days		
Nitrogen, (NO_3 & NO_2)	28 days		
Nitrogen, total kjeldahl (TKN)	28 days		
Nitrogen, total organic	28 days		
Phosphorus, total (phosphate, total on request sheet)	28 days		
Hardness, calcium	14 days		
Hardness, total	14 days		

All plastics are single-use. Store on ice at ≤6°C.

Powder-free gloves must be worn when collecting nutrients.

TDH Metals Analyses Available

Test	Holding Time	Container	Preservative
Aluminum, Al	6 months	1 liter plastic	5 mL 70% Nitric Acid (HNO_3)
Antimony, Sb			
Arsenic, As			
Barium, Ba			
Beryllium, Be			
Cadmium, Cd			
Calcium, Ca			
Chromium, Cr			
Cobalt, Co			
Copper, Cu			
Iron, Fe			
Lead, Pb			
Magnesium, Mg			
Manganese, Mn			
Nickel, Ni			
Potassium, K			
Selenium, Se			
Silver, Ag			
Sodium, Na			
Thallium, Tl			
Vanadium, V			
Zinc, Zn			
Mercury, Hg	28 days	1 liter plastic (same as above) or 500 mL plastic*	5.0 mL (for 1L bottle) or 2.5 mL (for 500 mL bottle) 70% Nitric Acid (HNO_3)

All plastics are single-use. Store on ice at ≤6°C.

Trace metals and low-level mercury samples must be collected using the modified clean technique.

* 500 mL mercury bottles only need to be used for samples delivered to the Knoxville Lab or if mercury is the only metal that is being analyzed, otherwise, the 1-liter metals bottle is sufficient for mercury analysis.

TDH Miscellaneous Inorganic Analyses Available

Test	Holding Time	Container	Preservative
Cyanide	14 days	1 liter plastic	pH>12; 5 mL of 50% sodium hydroxide (NaOH) at collection. If KI paper indicates chlorine, add 0.6g ascorbic acid ($C_6H_8O_6$) before adding NaOH. If sulfides are detected by lead acetate paper, add 1g of Cadmium Chloride ($CdCl_2$) after adding NaOH.
Oil & Grease	28 days	1 liter glass, wide mouth with Teflon® lined lid	2 mL sulfuric acid (H_2SO_4)
Phenols, total	28 days	1 liter glass, amber	2 mL sulfuric acid (H_2SO_4)
Sulfide	7 days	500 mL glass	2 mL zinc acetate (ZnAc) in laboratory. 5 mL 50% sodium hydroxide (NaOH) in field.
Boron	6 months	125 mL plastic	0.75 mL hydrochloric acid (HCl)
Flash Point	None specified	16-ounce glass Teflon® lined lid	None
TCLP	28 days	16-ounce glass jar*	None
TOC	28 days	Four 40-mL amber glass vials	0.1 mL phosphoric acid (H_3PO_4)

All plastics are single-use. Store on ice at $\leq 6^oC$.
*Due to analysis requirements, this could require much more sample. (See Section II, Protocol C)

TDH Organic Analyses Available

Test	Holding Time	Container	Preservative
Base/Neutral/Acid Extractables			
NPDES Extrac.	7 days to extract; 40 days to analyze	One 1-gallon amber bottle, acetone-rinsed, and Teflon®-lined cap.	None
Pesticides/PCBs			
TAL Extrac.			
Nitrobodies			
Semivolatiles			
Volatiles and Petroleum Hydrocarbons			
NPDES Volatiles	14 days	Five 40-mL amber vials, Teflon®-lined septa caps, no headspace.	1:1 hydrochloric acid (HCl)
TAL Volatiles			
BTEX	14 days	Five 40-mL amber vials, Teflon®-lined septa caps, no headspace	1:1 hydrochloric acid (HCl)
GRO			
EPH	14 days	One 1-gallon amber bottle with Teflon® lined lid	1:1 Hydrochloric Acid (HCl)

Store on ice $\leq 6^oC$.
Contact the TDH Environmental Laboratory for collection instruction for other types of analyses.

Laboratory MDLs for Metals

Parameter	Units	Nashville TDH Lab		Jackson TDH Lab		Knoxville TDH Lab	
		MQL	MDL	MQL	MDL	MQL	MDL
Aluminum - Al	ug/L	10	2.6	500	190	10	1.3
Antimony - Sb	ug/L	1	0.17	2.0	0.56	1	0.12
Arsenic - As	ug/L	5	0.44	3	0.95	5	1.0
Barium - Ba	ug/L	5	0.65	100	47	5	0.34
Beryllium - Be	ug/L	1	0.15	0.10	0.040	1	0.16
Cadmium - Cd	ug/L	1	0.17	1.0	0.19	1	0.21
Calcium - Ca	mg/L	0.1	0.031	2	0.64	2	0.06
Chromium - Cr	ug/L	5	1.1	2.0	0.44	5	0.6
Cobalt - Co	ug/L	1	0.19	3	2.1	1	0.22
Copper - Cu	ug/L	1	0.33	2.0	0.77	1	0.87
Iron - Fe	ug/L	10	5.4	50	14	50	31
Lead - Pb	ug/L	1	0.32	3	0.44	1	0.21
Lithium - Li	ug/L	1	0.46	**x**	**x**	1	0.19
Magnesium - Mg	mg/L	0.1	0.020	0.4	0.067	0.4	0.01
Manganese - Mn	ug/L	1	0.39	20	10	1	0.22
Mercury - Hg	ug/L	0.2	0.037	0.2	0.063	x	x
Molybdenum - Mo	ug/L	1	0.67	3	0.80	1	0.19
Nickel - Ni	ug/L	1	0.21	3	1.5	1	0.15
Potassium - K	mg/L	0.1	0.023	0.4	0.32	0.4	0.14
Selenium - Se	ug/L	5	1.5	3	2.1	5	1.2
Silver - Ag	ug/L	0.25	0.079	1	0.33	0.25	0.014
Sodium - Na	mg/L	0.1	0.033	0.2	0.08	0.2	0.08
Thallium - Tl	ug/L	1	0.28	2	0.68	1	0.18
Uranium - U	ug/L	1	0.20	**x**	**x**	1	0.13
Vanadium - V	ug/L	5	1.3	3	1.7	5	0.14
Zinc - Zn	ug/L	5	2	5.0	3.0	5	0.76

x = Not Performed by Lab

Laboratory MDLs for Non-Metals (Inorganics)

Parameter	Units	Nashville TDH Lab		Jackson TDH Lab		Knoxville TDH Lab	
		MQL	MDL	MQL	MDL	MQL	MDL
Ammonia	mg/L	0.10	0.033	**x**	**x**	**x**	**x**
TKN	mg/L	0.50	0.13	**x**	**x**	**x**	**x**
Nitrate/Nitrite	mg/L	0.10	0.017	**x**	**x**	**x**	**x**
Nitrate	mg/L	0.050	0.0097	**x**	**x**	**x**	**x**
Nitrite	mg/L	0.050	0.0065	0.01	0.0015	0.01	0.0020
Orthophosphate	mg/L	0.012	0.0080	**x**	**x**	0.01	0.0038
Total Phosphorus	mg/L	0.050	0.012	**x**	**x**	**x**	**x**
TOC	mg/L	0.50	0.15	**x**	**x**	**x**	**x**
COD	mg/L	5.0	TBD	**x**	**x**	**x**	**x**
Sulfate	mg/L	2.5	0.29	5	0.78	5	0.80
Phenol	mg/L	**x**	**x**	**x**	**x**	**x**	**x**
Fluoride	mg/L	0.050	0.015	0.10	0.011	0.10	0.02
Cyanide	mg/L	0.050	0.0067	0.050	0.0038	**x**	**x**
Hardness (Total)	mg/L	5	*	5	0.61	5	*
Hardness, Calcium	mg/L	2	*	2	*	2	*
Alkalinity	mg/L	10		10	*	10	
Acidity	mg/L	10	*	10	*	10	*
BOD/CBOD	mg/L	2.0	*	2.0	*	2.0	*
Color	Color Units	5.0	*	5.0	*	5.0	*
MBAS	mg/L	0.025	0.021	0.025	0.0057	0.025	TBD
Turbidity	NTU	1	*	1	*	1	*
Settleable Solids	mg/L	0.10	*	0.10	*	0.10	*
Suspended Residue	mg/L	10	*	10	*	10	*
Dissolved Residue	mg/L	10	*	10	*	10	*
Total Residue	mg/L	10	*	10	*	10	*
Sulfide	mg/L	**x**	**x**	**x**	**x**	**x**	**x**
Chloride	mg/L	2.5	0.29	2	*	4	0.79
Hexavalent Chromium	mg/L	**x**	**x**	0.01	0.0027	0.01	0.008
Silica	mg/L	TBD	TBD	0.25	0.027	0.25	0.17
Conductivity	µmohms/cm	10	*	10	*	10	*
Residual Free Chlorine	mg/L	0.25	0.050	0.25	0.010	TBD	TBD
Boron	ug/L	250	21	**x**	**x**	**x**	**x**

TBD = To Be Determined
x = Not Performed by Lab
*** = MDL not required**

Laboratory MDLs for Pesticides (Nashville Lab)

Analyte	MDL	MQL	Units
2,4'-DDD	0.0012	0.010	µg/L
2,4'-DDE	0.0018	0.010	µg/L
2,4'-DDT	0.0040	0.010	µg/L
4,4'-DDD	0.0026	0.010	µg/L
4,4'-DDE	0.0037	0.010	µg/L
4-4'-DDT	0.0026	0.010	µg/L
a-BHC	0.0012	0.010	µg/L
a-Chlordane	0.00053	0.010	µg/L
a-Endosulfan / Endosulfan I	0.0021	0.010	µg/L
Aldrin	0.0017	0.010	µg/L
b-BHC	0.0018	0.010	µg/L
b-Endosulfan / Endosulfan II	0.0027	0.020	µg/L
Chlordane	0.020	0.050	µg/L
cis-Nonachlor	0.008	0.010	µg/L
d-BHC	0.0038	0.010	µg/L
Dieldrin	0.0026	0.010	µg/L
Endrin	0.0045	0.010	µg/L
Endrin Aldehyde	0.0014	0.010	µg/L
Endrin Ketone	0.0035	0.010	µg/L
Endosulfin sulfate	0.0043	0.010	µg/L
g-Chlordane	0.0036	0.010	µg/L
Heptachlor	0.0030	0.010	µg/L
Heptachlor epoxide	0.0015	0.010	µg/L
Hexachlorobenzene	0.0016	0.010	µg/L
Hexachlorocyclopentadiene	0.0022	0.010	µg/L
Lindane / g-BHC	0.0036	0.010	µg/L
Methoxychlor	0.027	0.050	µg/L
o,p'-DDD	0.0012	0.010	µg/L
o,p'-DDE	0.0018	0.010	µg/L
o,p'-DDT	0.0040	0.010	µg/L
Oxychlordne	0.0045	0.010	µg/L
p,p'-DDD	0.0026	0.010	µg/L
p.p'-DDE	0.0037	0.010	µg/L
p,p'-DDT	0.0069	0.010	µg/L
Propachlor	0.0030	0.010	µg/L
Toxaphene	0.080	0.10	µg/L
trans-Nonachlor	0.0011	0.010	µg/L
Trifluralin	0.0014	0.010	µg/L

Laboratory MDLs for PCBs (Nashville Lab)

Analyte	MDL	MQL	Units
PCB-1016	0.030	0.20	µg/L
PCB-1221	0.070	0.40	µg/L
PCB-1232	0.060	0.20	µg/L
PCB-1242	0.030	0.20	µg/L
PCB-1248	0.060	0.20	µg/L
PCB-1254	0.080	0.10	µg/L
PCB-1260	0.050	0.10	µg/L

Laboratory MDLs for PAHs (Nashville Lab)

Analyte	MDL	MQL	Units
Acenaphthene	2.0	10	µg/L
Acenaphthylene	2.3	10	µg/L
Anthracene	0.086	0.50	µg/L
Benzo(a)anthracene	0.010	0.010	µg/L
Benzo(a)pyrene	0.010	0.050	µg/L
Benzo(b)fluoranthene	0.010	0.010	µg/L
Benzo(g,h,i)perylene	0.0072	0.010	µg/L
Benzo(k)fluoranthene	0.0020	0.010	µg/L
Chrysene	0.50	0.50	µg/L
Dibenzo(a,h)anthracene	0.10	0.10	µg/L
Fluoranthene	0.12	0.50	µg/L
Fluorene	0.25	1.0	µg/L
Indeno(1,2,3-cd)pyrene	0.015	0.10	µg/L
Naphthalene	3.1	10	µg/L
Phenanthrene	0.085	0.50	µg/L
Pyrene	0.061	0.50	µg/L

Laboratory MDLs for Semivolatiles (Nashville Lab)

Analyte	MDL	MQL	Units
1,1'-Biphenyl	0.050	2.0	µg/L
1,2,4,5 Tetrachlorobenzene	0.120	2.0	µg/L
1,2,4-Trichlorobenzene	0.070	2.0	µg/L
2,4,5-Trichlorophenol	0.060	2.0	µg/L
2,4,6-Tribromophenol	0.090	2.0	µg/L
2,4,6-Trichlorophenol	0.090	2.0	µg/L
2,4-Dichlorophenol	0.070	2.0	µg/L
2,4-Dimethylphenol	0.060	2.0	µg/L
2,4-Dinitrophenol	0.26	10	µg/L
2,4-Dinitrotoluene	0.20	2.0	µg/L
2,6-Dinitrotoluene	0.060	2.0	µg/L
2-Chloronaphthalene	0.060	2.0	µg/L
2-Chlorophenol	0.060	2.0	µg/L
2-Fluorobiphenyl	0.080	2.0	µg/L
2-Fluorophenol	0.070	2.0	µg/L
2-Methylnaphthalene	0.070	2.0	µg/L
2-Methylphenol	0.060	2.0	µg/L
2-Nitroaniline	0.17	2.0	µg/L
2-Nitrophenol	0.07	2.0	µg/L
3,3'-Dichlorobenzidine	1.0	2.0	µg/L
3-Nitroaniline	0.20	2.0	µg/L
4,6-Dinitro-2-methylphenol	0.66	5.0	µg/L
4-Bromophenyl-phenylether	0.050	2.0	µg/L
4-Chloro-3-methylphenol	0.060	2.0	µg/L
4-Chloroaniline	0.18	2.0	µg/L
4-Chlorophenyl-phenylether	0.15	2.0	µg/L
4-Methylphenol	0.06	2.0	µg/L
4-Nitroaniline	0.20	5.0	µg/L
4-Nitrophenol	0.55	5.0	µg/L
Acenaphthene	0.15	2.0	µg/L
Acenaphthylene	0.070	2.0	µg/L
Acetophenone	0.060	2.0	µg/L
Anthracene	0.060	2.0	µg/L
Atrazine	0.080	2.0	µg/L
Azobenzene	0.53	2.0	µg/L
Benzaldehyde	0.29	2.0	µg/L
Benzidine	0.30	10	µg/L
Benzo(k)fluoranthene	0.080	2.0	µg/L

Analyte	MDL	MQL	Units
Benzo[a]anthracene	0.080	2.0	µg/L
Benzo[a]pyrene	0.070	2.0	µg/L
Benzo[b]fluoranthene	0.060	2.0	µg/L
Benzo[g,h,i}Perylene	0.53	2.0	µg/L
Benzoic Acid	0.74	2.0	µg/L
Benzyl Alcohol	0.050	2.0	µg/L
Bis(2-chloroethoxy)methane	0.060	2.0	µg/L
Bis(2-chloroethyl)ether	0.060	2.0	µg/L
Bis(2-chloroisopropyl)ether	0.40	2.0	µg/L
Bis(2-ethylhexyl)phthalate	0.090	2.0	µg/L
Butylbenzylphthalate	0.070	2.0	µg/L
Caprolactam	0.080	2.0	µg/L
Carbazole	0.060	2.0	µg/L
Chyrsene	0.050	2.0	µg/L
Dibenzo[a,h]anthracene	0.15	2.0	µg/L
Dibenzofuran	0.080	2.0	µg/L
Diethylphthalate	0.070	2.0	µg/L
Dimethylphenthalate	0.060	2.0	µg/L
Di-n-butylphthalate	0.070	2.0	µg/L
Di-n-octylphthalate	0.13	2.0	µg/L
Fluoranthene	0.070	2.0	µg/L
Fluorene	0.060	5.0	µg/L
Hexachlorobenzene	0.070	2.0	µg/L
Hexachlorobutadiene	0.07	2.0	µg/L
Hexachlorocyclopentadiene	0.12	2.0	µg/L
Hexachloroethane	0.090	2.0	µg/L
Indeno[1,2,3-cd]pyrene	0.49	2.0	µg/L
Isophorone	0.070	2.0	µg/L
Naphthalene	0.060	2.0	µg/L
Nitrobenzene	0.070	2.0	µg/L
N-Nitrosodimethylamine	0.080	2.0	µg/L
N-Nitroso-di-n-propylamine	0.060	2.0	µg/L
N-Nitrosodiphenylamine	0.070	2.0	µg/L
Pentachlorophenol	0.57	10	µg/L
Phenanthrene	0.16	2.0	µg/L
Phenol	0.050	2.0	µg/L
Pyrene	0.070	2.0	µg/L
Pyridine	0.10	2.0	µg/L
Quinolin	0.50	2.0	µg/L
Resorcinol	0.44	2.0	µg/L

Laboratory MDLs for Volatiles (Nashville Lab)

Analyte	MDL	MQL	Units
1,1,1,2-Tetrachloroethane	1.0	5.0	µg/L
1,1,1-Trichloroethane	0.53	5.0	µg/L
1,1,2,2-Tetrachloroethane	1.1	2.0	µg/L
1,1,2-Trichloro-1,1,2-trifluoroethane	2.5	5.0	µg/L
1,1,2-Trichloroethane	0.49	5.0	µg/L
1,1-Dichloroethane	0.67	1.0	µg/L
1,1-Dichloroethene	0.18	1.0	µg/L
1,1-Dichloropropene	2.3	5.0	µg/L
1,2,3-Trichlorobenzene	1.6	5.0	µg/L
1,2,3-Trichloropropane	0.65	5.0	µg/L
1,2,4-Trichlorobenzene	0.59	5.0	µg/L
1,2,4-Trimethylbenzene	0.46	5.0	µg/L
1,2-Dibromo-3-chloropropane	4.5	20	µg/L
1,2-Dibromoethane	0.54	5.0	µg/L
1,2-Dichlorobenzene	0.42	5.0	µg/L
1,2-Dichloroethane	0.19	1.0	µg/L
1,2-Dichloropropane	0.46	5.0	µg/L
1,3,5-Trimethylbenzene	0.66	5.0	µg/L
1,3-Dichlorobenzene	0.54	5.0	µg/L
1,3-Dichloropropane	0.31	2.0	µg/L
1,4-Dichlorobenzene	0.41	2.0	µg/L
2,2-Dichloropropane	0.76	5.0	µg/L
2-Butanone (MEK)	1.4	10	µg/L
2-chloroethyl vinyl ether	1.4	8.0	µg/L
2-Chlorotoluene	0.75	5.0	µg/L
2-Hexanone	1.1	5.0	µg/L
4-Chlorotoluene	0.64	5.0	µg/L
4-Methyl-2-pentanone	0.78	2.5	µg/L
Acetone	0.97	2.5	µg/L
Acrolein	8.0	25	µg/L
Acrylonitrile	2.3	5.0	µg/L
Benzene	0.28	2.0	µg/L
Bromobenzene	0.48	5.0	µg/L
Bromochloromethane	0.92	2.0	µg/L
Bromodichloromethane	0.67	5.0	µg/L
Bromoform	0.52	5.0	µg/L
Bromomethane	5.0	5.0	µg/L

Analyte	MDL	MQL	Units
Carbon disulfide	0.53	1.0	µg/L
Carbon tetrachloride	0.44	5.0	µg/L
Chlorobenzene	0.38	2.0	µg/L
Chloroethane	5.0	5.0	µg/L
Chloroform	0.51	2.0	µg/L
Chloromethane	2.3	5.0	µg/L
cis-1,2-Dichloroethene	0.46	1.0	µg/L
cis-1,3-Dichloropropene	0.78	5.0	µg/L
Cyclohexane	0.52	5.0	µg/L
Dibromochloromethane	0.61	5.0	µg/L
Dibromomethane	0.78	5.0	µg/L
Dichlorodifluoromethane	3.9	5.0	µg/L
Diisopropyl ether	1.50	5.0	µg/L
Ethylbenzene	0.51	5.0	µg/L
Hexachlorobutadiene	2.1	10	µg/L
Isopropylbenzene	0.27	2.0	µg/L
m & p-xylene	0.96	10	µg/L
Methyl acetate	1.1	2.0	µg/L
Methylcyclohexane	0.72	5.0	µg/L
Methylene chloride	0.27	2.0	µg/L
Methyl-*t*-butyl ether	0.37	2.0	µg/L
Naphthalene	0.90	5.0	µg/L
n-Butylbenzene	0.43	2.0	µg/L
n-Propylbenzene	0.28	2.0	µg/L
o-Xylene	0.58	5.0	µg/L
p-isopropyl toluene	0.25	2.0	µg/L
sec-Butylbenzene	0.51	2.0	µg/L
Styrene	0.46	5.0	µg/L
tert-Butylbenzene	0.22	2.0	µg/L
Tetrachloroethene	1.9	5.0	µg/L
Toluene	0.36	2.0	µg/L
trans-1,2-Dichloroethene	0.34	2.0	µg/L
trans-1,3-Dichloropropene	0.18	1.0	µg/L
Trichloroethene	0.95	5.0	µg/L
Trichlorofluoromethane	0.26	2.0	µg/L
Vinyl acetate	0.35	1.0	µg/L
Vinyl chloride	1.6	5.0	µg/L

APPENDIX C

Monitoring to Support TMDL Development

TMDL: Monitoring to support pollutant-specific TMDL development depends on the TMDL type. Coordinate TMDL monitoring with the Watershed Management Section.

a. Metal TMDLs (Minimum number of data points at each site is 12, some data points are obtained at low flow conditions).

- Critical: Flow, Hardness as $CaCO_3$, TSS, TOC, Metal(s) on 303(d) List, Selenium, pH, temperature, conductivity, and DO.
- Noncritical: Dissolved Metals (Cd, Cu, Pb, Ni, Ag, Zn).

b. pH TMDL (Minimum number of data points at each site is 12, some data points are obtained at low flow conditions).

- Critical: Acidity, Alkalinity, Flow, Hardness as $CaCO_3$, TSS, TOC, pH, temperature, conductivity, and DO.

c. DO TMDLs (Minimum number of data points at each site is 12, some data points are obtained at low flow conditions).

- Critical: Flow, pH, temperature (water), conductivity, DO, diurnal DO (minimum 2 weeks during growing season), $CBOD_5$, NH_3, NO_2/NO_3, Total Phosphorus (Total Phosphate on lab request sheet), Total Kjeldahl Nitrogen, and channel cross-section (transect profile, width, and depth).
- Noncritical: Velocity (dye study), temperature (air), CBOD decay rate, $CBOD_{ultimate}$, re-aeration rate, SOD, chlorophyll *a*, field notes (weather conditions, presence of algae, point source discharge, etc.).

d. Nutrient TMDLs (Minimum of 12 monthly samples, minimum of four high-flow samples).

- Critical: Flow, NH_3, NO_2/NO_3, Total Phosphorus (listed as total phosphate on lab request sheet), Orthophosphate, Total Kjeldahl Nitrogen, TSS, Turbidity, TOC, periphyton (wadeable) or chlorophyll *a* (non-wadeable), pH, temperature, conductivity, DO, and Diurnal DO (minimum 2 weeks during growing season).
- Noncritical: Project specific and weather conditions.

e. Pathogen TMDLs (Minimum of 12 monthly samples, minimum of four high-flow samples)

- Critical: Fecal coliform, *E. coli*, TSS, Turbidity, pH, temperature, conductivity, and DO, and comments describing flow conditions.
- Noncritical: Flow measurements, weather conditions.

Guidelines for collection of high-flow samples:

During wet season (January to March): ≥ 0.25 inches of rain in last 24 hours prior to sample collection.

During dry season (August to October): ≥ 0.5 inches of rain in last 24 hours prior to sample collection.

Storm Event Characterization

Level I:

Collect a minimum of 3 samples during each storm event with the objective of collecting at least one sample during each phase of the storm hydrograph: rising limb, near the peak, and on the recession.

Level II:

Collect 6-10 samples during each storm with the objective of fully representing the storm hydrograph: 2-3 samples on the rising limb, 1-2 at or near the peak, and 3-5 on the recession of the hydrograph.

Characterize storms during seasonal wet (January-March) and dry (August-October) periods (at least one storm each) in order to differentiate seasonal characteristics.

Wet season storm events tend to be longer duration (days) and may require more samples, on average, than dry season storm events with shorter duration (hours).

General storm event characterization guidelines:

During wet season (January to March): ≥ 0.25 inches of rain in last 24 hours prior to sample collection.

During dry season (August to October): ≥0.5 inches of rain in last 24 hours prior to sample collection.

> **Note**: Many factors (antecedent moisture conditions, drainage area, rainfall intensity, land use, soil permeability, ground cover, etc.) can affect the stormflow runoff potential and dynamics in a watershed. The above are guidelines only; best professional judgment should be used.

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To reach your local
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